ECOLOGY OF FISHES IN TASEK BERA, PAHANG, MALAYSIA

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THESIS SUBMITTED IN FULLFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

FACULTY OF SCIENCE
UNIVERSITY OF MALAYA
KUALA LUMPUR

2012

UNIVERSITI MALAYA

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ABSTRACT

The ecology of fishes was investigated in Tasek Bera (Lake Bera), a peat swamp ecosystem with three major habitats: (i) swamp forest dominated by *Eugenia*, (ii) Reed (*Lepironia*) and clumps of *Pandanus* stands and (iii) open waters fringed by submerged *Utricularia*. Limnological information and fish fauna of the lake was determined and the association of both data was done using canonical correspondence analysis (CCA). Mean values of water quality parameters for the entire study period (April 2004 to December 2005) were as follows: water temperature = 29.54^0 C ± 1.15; total suspended solids (TSS) = 19.38 mg/L ± 28.32; total dissolved solids (TDS) = 31.64 mg/L ± 4.87; turbidity = 8.03 NTU ± 4.61; conductivity = 44.85 µS/cm ± 5.65; dissolved oxygen (DO) = 3.66 mg/L ± 1.28; pH = 5.77 ± 0.76; hydrogen sulphide = 1.11 µg/L ± 3.16; nitrite = 4.63 µg/L ± 9.81; ammonium = 67.80 µg/L ± 66.71; ammonia = 0.38 µg/L ± 0.46. There were statistically significant differences in values of water quality parameters across sampling stations and depths. Only TSS, TDS, conductivity and DO were not significantly different during three sampling times (0600, 1400 and 2200 hours). Temperature and conductivity were higher compared to 30 years ago. Whereas, pH, nitrite and ammonium were lower than 30 years ago.

The ichthyofaunal composition of Tasek Bera based on museum collections and present collections of fish revealed that 95 species representing 22 families were known to inhabit the wetlands. Four species were considered to be locally extinct, while 66 species were considered to be extremely rare or rare. The rare and much sought after Asian bonytongue, *Scleropages formosus* was still present as it was collected during the sampling effort. *Botia hymenophysa* which was recorded as a dominant species in the past is now difficult to find. Fourteen species were recorded for the first time in the area. They include: *Amblyrhynchichthys truncatus, Boraras maculates*, *Chela laubuca, Epalzeorhynchos kalopterus, Macrochirichthys macrochirus* and *Osteochilus*

microcephalus of the family Cyprinidae; *Acanthopsoides molobrion, Lepidocephalichthys furcatus* and *Pangio malayana* of the family Cobitidae; *Channa gachua* of the family Channidae; *Kryptopterus moorei* of the family Siluridae; *Akysis alfredi* of the family Akysidae; *Macrognathus maculatus* of the family Mastacembelidae and *Betta waseri* of the family Osphronemidae. The most common species were *Labiobarbus festivus* and *Cyclocheilichtys apogon* both from the family Cyprinidae. Based on past and current studies, a total of 144 species has been reported from Tasek Bera includes several doubtful occurrences and incomplete identification.

The vertical distribution of fishes investigated at 11 study sites by using vertical gill nets revealed that Lubuk Salleh has the highest diversity and biomass compared to other study sites. Cyprinids *Labiobarbus festivus* (ikan kawan) and *Hampala macrolepidota* (ikan sebarau) were found at all sites. *Barbonymus schwanenfeldii, Cyclocheilichthys apogon, Hampala macrolepidota, Labiobarbus festivus* and *Kryptopterus apogon* occurred at almost all depth layers. Depth 0 to 1 m had the highest diversity followed by depth 2 to 3 m and depth 1 to 2 m. Catch per unit effort (CPUE) and abundance of species were much higher during evening and night compared to the early part of the day. A canonical correspondence analysis (CCA) showed that depth, dissolved oxygen and pH were the most important factors influencing the vertical distribution of the fish species.

The most successful species in Tasek Bera, *Labiobarbus festivus* has inferior mouth with upper and lower jaws protrusive and toothless. Both jaws have truncate unculi with polygonal borders. The gill has short gill rakers with the space between adjacent rakers not very closely packed. Relative Important Index (%) of *L. festivus* diet show that algae represented 55.7%, followed by detritus and plant (26.8%) and zooplankton (17.5%). Bacillariophyta is the most important component in term of number, whereas detritus and plant contributed more than 50% in terms of volume. From the recent study *L. festivus* can be generalised as an omnivore.

ABSTRAK

Satu kajian ekologi ikan telah dijalankan di Tasek Bera, Pahang, yang merupakan ekosistem paya gambut terdiri dari tiga jenis habitat utama: (i) hutan paya didominasi oleh pokok *Eugenia*, (ii) rimbunan rumput *Lepironia* dan kelompok pokok pandan (*Pandanus*) dan (iii) kawasan air terbuka dipagari *Utricularia*. Informasi berkaitan limnologi dan fauna ikan tasik ini telah dikaji dan hubungan kedua-dua data kajian telah dianalisis menggunakan "canonical correspondence analysis (CCA)". Nilai purata parameter-parameter air yang diukur sepanjang kajian dijalankan (April 2004 hingga Disember 2005) adalah seperti berikut: suhu air = 29.54^0 C ± 1.15; jumlah pepejal terapung (TSS) = 19.38 mg/L ± 28.32; jumlah pepejal terlarut (TDS) = 31.64 mg/L ± 4.87; turbiditi = 8.03 NTU ± 4.61; konduktiviti = 44.85 µS/cm ± 5.65; oksigen terlarut (DO) = 3.66 mg/L ± 1.28; pH = 5.77 ± 0.76; hidrogen sulfida = 1.11 µg/L ± 3.16; nitrit = 4.63 µg/L ± 9.81; ammonium = 67.80 µg/L ± 66.71; ammonia = 0.38 µg/L ± 0.46. Analisis statistik menunjukkan nilai-nilai parameter kualiti air adalah berbeza dengan bererti antara stesen-stesen kajian dan juga kedalaman. Jumlah pepejal terampai, jumlah pepejal terlarut, konduktiviti dan oksigen terlarut tidak berbeza dengan bererti antara tiga waktu pensampelan dijalankan (0600, 1400 and 2200 jam). Bacaan suhu dan konduktiviti kajian terkini adalah lebih tinggi berbanding 30 tahun yang lalu. Manakala, pH, nitrit dan ammonium agak rendah berbanding 30 tahun lalu.

Komposisi iktiofauna Tasek Bera berdasarkan koleksi muzium dan pensampelan ikan terkini menunjukkan sejumlah 95 spesies mewakili 22 famili menghuni habitat-habitat di kawasan tersebut. Empat spesies telah dianggap mengalami kepupusan setempat, manakala 66 spesies dianggap jarang atau sangat jarang ditemui. Ikan kelisa, *Scleropages formosus* yang sukar ditemui dan sering menjadi buruan masih terdapat di kawasan tersebut dan berjaya ditangkap semasa penyampelan. *Botia hymenophysa* yang pernah direkod sebagai spesies dominan kini sukar ditemui. Empat belas spesies direkod

buat pertama kali di sini. Spesies tersebut adalah: *Amblyrhynchichthys truncatus, Boraras maculates*, *Chela laubuca, Epalzeorhynchos kalopterus, Macrochirichthys macrochirus* dan *Osteochilus microcephalus* dari famili Cyprinidae; *Acanthopsoides molobrion, Lepidocephalichthys furcatus* dan *Pangio malayana* dari famili Cobitidae; *Channa gachua* dari famili Channidae; *Kryptopterus moorei* dari famili Siluridae; *Akysis alfredi* dari famili Akysidae; *Macrognathus maculatus* dari famili Mastacembelidae dan *Betta waseri* dari famili Osphronemidae. Spesies yang paling biasa ditemui di sini ialah *Labiobarbus festivus* (ikan kawan) dan *Cyclocheilichtys apogon* (ikan kemperas) kedua-duanya dari famili Cyprinidae. Berdasarkan kajian ini dan terdahulu, sejumlah 144 spesies telah dilaporkan dari Tasek Bera tetapi termasuk beberapa spesies yang dicurigai serta tidak dikenalpasti secara lengkap.

Kajian taburan ikan secara menegak di 11 tapak kajian menggunakan pukat insang menunjukkan Lubuk Salleh mempunyai diversiti dan biojisim yang tertinggi berbanding kawasan-kawasan kajian yang lain. Ikan Cyprinid, *Labiobarbus festivus* (ikan kawan) dan *Hampala macrolepidota* (ikan sebarau) telah ditemui di kesemua tapak kajian. *Barbonymus schwanenfeldii, Cyclocheilichthys apogon, Hampala macrolepidota, Labiobarbus festivus* dan *Kryptopterus apogon* muncul di hampir setiap lapisan kedalaman. Kedalaman 0 hingga 1 m menunjukkan diversiti yang tertinggi diikuti kedalaman 2 hingga 3 m dan 1 hingga 2 m. Tangkapan per unit usaha (CPUE) dan kelimpahan spesies adalah tertinggi pada waktu petang dan malam berbanding awal pagi. Hasil analisis "canonical correspondence analyses (CCA)" menunjukkan bahawa kedalaman, oksigen terlarut dan pH adalah faktor-faktor terpenting mempengaruhi taburan menegak spesies ikan di sini.

Spesies ikan yang paling berjaya di Tasek bera, *Labiobarbus festivus* mempunyai mulut jenis ke bawah atau " inferior" dengan rahang atas dan bawah yang boleh dijulur keluar dan tidak mempunyai gigi. Kedua-dua rahang mempunyai struktur "unculi" yang pendek dengan tapak berbentuk poligon. Ia mempunyai sikat insang yang pendek dan tidak tersusun rapat antara satu sama lain. Indeks Kepentingan Relatif (%) spesies ini menunjukkan bahan makanan terpenting iaitu alga mewakili 55.7%, diikuti oleh detritus dan sisa tumbuhan (26.8%) serta zooplankton (17.5%). Basillariofita merupakan komponen terpenting dari segi bilangan manakala detritus dan tumbuhan menyumbang lebih dari 50% dari segi isipadu. Daripada kajian ini, *L. festivus* boleh dikategorikan sebagai omnivor.

ACKNOWLEDGEMENTS

With the grace of Ar-Rahman and Ar-Rahim.

First and foremost, I would like to express my utmost gratitude and sincere thanks to my supervisors, Prof. Dr. Mohd Zakaria Ismail and Prof. Dato' Dr. Sofian Azirun, for the valuable contribution, supervision, advice, guidance and patience throughout the course of my study. In addition, a very special thanks to Dr. Sasekumar, Prof. Chong Ving Ching and my husband, Muhammad Ali for their constructive comments and critical review of this work. I am also grateful to MOSTE for the NSF scholarship, which allowed me to conduct the bulk of my research work.

I would also like to express my appreciation to all the staff of ISB especially Abg Zul, Abg Azhar, Fauzi, Nizam, Ponniah, Abg Rosli and Abg Mat, Abg Rosli, Abg Rozaimai, Pak Cik Raman, Pak Cik Stem and Rudin, who assisted me during the field sampling.

My sincere thanks also goes to all my dearest lab mates, including Kak Honey, Kak Yan, Kak Gima, Kak Yong, Abg Ayun, Shikin, Zaiti, Sumayah, Mirfat, Fatma, Ami, Daliza and Sueria Harti and many others (Kak Ruzaimah, Kak Shamsiah and Kak Saida) for their friendships, support and company all the way.

To my mum, my sisters, brothers and my parents in-laws, thank you for taking care of my daughter Aishah and I.

To everybody in ISB I will never forget the cooperation and kindness to make things easier for me.

To my dearest Kak Pah, Kak Badriyah, Kak Hanisah, Prof Azizi, Zakiah, Fitri, Juju and others in UPM thank you for everything that we shared.

Lots of love, Fatin

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CHAPTER 1

GENERAL INTRODUCTION

1.1 STUDIES ON FRESHWATER FISH ECOLOGY IN MALAYSIA

There are very few studies on the ecology of fishes in the freshwater ecosystems in Malaysia. Most of the available literatures were from studies conducted several decades ago. An example of one of the most comprehensive study was on diversity of fishes in rivers flowing in rainforest carried out by Inger and Chin (1962) in Sabah, which is in East Malaysia and sometimes known as part of Malaysian Borneo. They recorded 168 species of freshwater fishes, including 62 species endemic to Borneo and 29 species endemic to North Borneo. Mountain streams yielded endemic substrate-clinging species of fishes such as *Gastromyzon, Glaniopsis, Protomyzon* and *Neogastromyzon* which were found especially in Kinabalu Park. In another study, Johnson (1967a) related water chemistry with distribution and composition of freshwater fishes in Peninsular Malaysia excluding Tasek Bera in Pahang. Bishop (1973) conducted an intensive hydrology study in a small unaltered river, the Gombak River, a tributary of the Klang River. This study included a chapter on the composition, longitudinal succession, feeding segregation, diversity, trophic relationships and appraisal of the fish population.

More recently, papers published by Zakaria-Ismail and Sabariah (1994) reported on ecological studies in Kanching River and its tributaries in Selangor, and presented information on the influence of habitat structure on species composition, standing biomass and species richness of fishes. In another study, Zakaria-Ismail and Sabariah (1995) studied patterns of distribution and diversity of fishes in various habitats in Temenggor Lake, Perak. The relationship between fishes and habitats in rainforest streams in Sabah was studied by Martin-Smith (1998), where he used principal component analysis to categorise various habitats based on fish abundance and biomass data to confirm the existence of a specialised assemblage of fishes in riffle areas of streams.

Several studies on peat swamp fish fauna in Malaysia have been published. In these swamps, the highly acidic tea-colored water (black waters), was once considered to have low biodiversity and productivity (e.g. Johnson, 1968) and host very specialised organisms especially endemic freshwater fishes. Yule (2010) stated that the tropical peat swamp forests of Indonesia and Malaysia are unique ecosystems having endemic species of flora, fauna and microbes even though the waters are extremely acidic, anaerobic and poor in nutrients. Studies by Ng *et al.* (1994) and Ng (1994) particularly in North Selangor, listed some 55 species from Peninsula Malaysia peat swamps; representing 18% of the total Malaysian fish fauna. Ng (1994) also noted that many of the most popular ornamental fishes are caught from peat swamps. Mansor *et al*. (1999) recorded 42 species of fishes in a swamp forest of Pondok Tanjung Forest Reserve, Perak, while Zakaria-Ismail (1999) recorded 33 fish species in Nenasi Forest Reserve, Pahang. In the disturbed Paya Beriah Peat Swamp Forest, Shah *et al.* (2006) discovered a total of 32 fish species with the loss of endemic and rare species, such as *Sphaerichthys osphromenoides* (chocolate gourami) and *Luciocephalus pulcher* (pikehead), which had been recorded in the past.

In 2006, the world's smallest fish, *Paedocypris progenatica* was discovered by Kottelat *et al.* (2006) in peat swamp with black water streams and pools from Sumatra and Bintan Island (Indonesia) and Kuching (Malaysia). They also mentioned that 27 of 47 miniature Asian freshwater fishes listed by Kottelat and Vidthayanon (1993), inhabit black water and peat swamps. Report by Wetlands International (2010) stated that the world's 'second smallest fish', the 'Perak fish' (an undescribed *Paedocypris* sp.), was also discovered in the Paya Beriah, Perak.

Tasek Bera is an example of peat swamp habitat and has been extensively studied from the point of limnology (Furtado and Mori, 1982). They emphasised on production and decomposition processes in relations to the environment. This included ecological notes on fishes conducted by a group of researchers from Japan and University of Malaya involved in a scientific exploration that took place around Pos Iskandar, in southwestern part of the swamp. Since then, no other ecological study has been conducted at Tasek Bera. However, Khan (1996) and Sim (2002) published checklists of later surveys of fish diversity in Tasek Bera. More recently, Chong (2007) reported water quality degradation of Tasek Bera from anthropogenic activities including surface run off of nutrient-rich agriculture input, logging activities and oil discharge from motorboats.

The intention of this study is to assess the current ecological state of Tasek Bera since it was first documented 30 years ago by Furtado and Mori (1982), especially on the fish ecology. Over the past 30 years, the surrounding areas have changed tremendously from the perspective of land use. Currently, Tasek Bera is surrounded with oil palm and rubber plantations under the Federal Land Development Authority (FELDA) scheme. More than 50 percent of the original buffer zone areas have been converted to oil palm and rubber cultivation (O'Connor, 1996). Despite these changes, it is hypothesised that the water quality of the swamp has not changed drastically and the fish species composition of the area remains the same. It is also speculated that the fish diversity and abundance is related to the water parameters, depth and time.

1.2 INTRODUCTION TO TASEK BERA

Tasek Bera is the largest natural freshwater lake in Peninsula Malaysia. In this study, Tasek Bera refers to the lake component of the Tasek Bera peat swamp. The Malay language or Bahasa Malaysia word “Tasek” is translated to the word “Lake”. Tasek Bera is a low-lying alluvial peat and freshwater swamp system, and also a blackwater ecosystem. The swamp has complex tracts of water occurring among wide areas of reed, forest, and patches of high ground. The first Ramsar site in Malaysia established in 1994, the lake is protected under the Ramsar Convention, an inter-governmental agreement adopted in 1971 for the conservation and sustainable utilisation of the wetland. Tasek Bera is located at 02º58’N 102º36’E, in the central lowlands of Peninsular Malaysia (Fig. 1.1). The watershed of Tasek Bera covers some 61,383 ha of undulating plains between the main and eastern ranges of Peninsular Malaysia. The wetland itself occupies over 6,800 ha where the main habitats are open waters (Fig. 1.2), rivers and streams (Fig.1.3), reed-bed *Lepironia* (Fig. 1.4) and *Pandanus* (Fig. 1.5) swamps areas. Tasek Bera consists of a network of third and fourth order streams and swamp channels. These swamps are Paya (Paya = Swamp) Kelatung, Paya Chenderong, Tasek Dampar, Paya Burung Bangkung and Paya Lengut. In the surrounding area, seasonal extension of the freshwater swamp inundate the surrounding forest, which is dominated by *Eugenia* and surrounded by lowland dipterocarp forest. Runoff from the surrounding area is stored in the lake, which reduce flooding. The organic matter forming thick peat functions as a sponge that also holds water. Water from the wetland flows through Tasek River northwards into Bera River, which then flows into Pahang River, heading eastwards into the South China Sea.

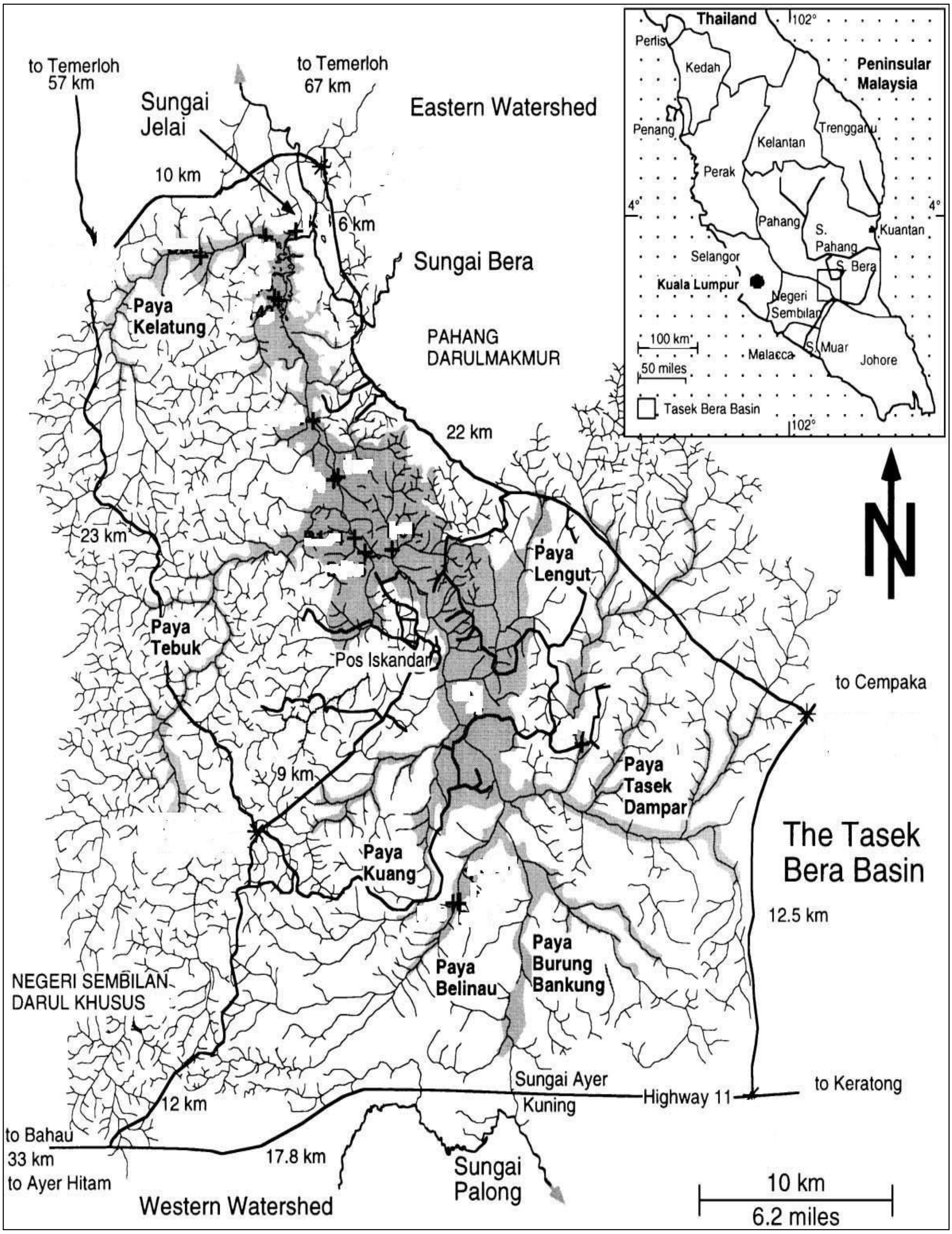


Figure 1.1 Location of Tasek Bera in the state of Pahang, Peninsular Malaysia (Source: Khan *et al.,* 1996). *(Sungai = River).*

Figure 1.2 Open water body (Lubuk Kuin) feature in Tasek Bera.

Figure 1.3 Tasek River, the main outlet of Tasek Bera which leads to Bera River.

Figure 1.4 Reed-bed *Lepronia* sp. of Tasek Bera

Figure 1.5 Rassau (*Pandanus* sp.) of Tasek Bera

1.3 OBJECTIVES OF STUDY

In order to study the ecology of fishes in Tasek Bera, the following investigations were carried out:

a. To assess the water parameters including temperature, total suspended solids, turbidity, pH, conductivity, total dissolved solids, hydrogen sulphide, ammonium, ammonia, nitrite and dissolved oxygen;
b. To determine fish faunal assemblages and extending the survey area from previous studies which focused mainly around Pos Iskandar to include Lubuk Kuin, Lubuk Benar, Lubuk Cenderong and Paya Jelawat;
c. To determine the vertical distribution of fishes and its relations to the environmental parameters and time,
d. To delve into the diet preference and morphological mouth characteristic as the basis to success of a species found in the peat swamp ecosystem.

CHAPTER 2

PHYSICAL AND CHEMICAL PARAMETERS OF TASEK BERA

2.1 INTRODUCTION

Peat swamp forests in Malaysia cover approximately 1.54 million hectares, with less than twenty percent found in Peninsular Malaysia. Over the years, these swamps have been cleared and drained for agriculture, settlement and for other human activities, thus completely altering natural ecosystems and destroying the unique flora and fauna associated with these ecosystems. Loss of peat swamps forest also play a major role in climate change as they form carbon sinks, which store more carbon per unit area than any other ecosystems in the world (UNDP, 2006). Tasek Bera is part of the extensive peat swamps found in Pahang, and over the past 20 years has been impacted by various activities such as illegal logging, agricultural activities and unsustainable development in the surrounding areas of the lake (IPT-Asian Wetland Bureau, 1993). Expanding agriculture is a major threat to the lake's water quality as some plantations (oil palm and rubber) are close to the edge of the lake water body.

Developmental activities result in environmental damage to the adjacent peat swamp by changing the water quality characteristics, which in the long term could lead to deterioration in the integrity of the peat swamp. Burning of *Pandanus helicopus* by the Semalai tribe is a common technique for tortoise hunting. Following the burning, *Lepironia articulata* (Cyperaceae) replaces *P. helicopus* (Pandanaceae), contributing to an increase of ash-yield towards the surface (Wüst and Bustin, 2004). In addition, the applications of herbicides and pesticides in agricultural practices have been shown elsewhere to affect fish existence and even destroy whole fish populations by diminishing productivity and fecundity (Sigmon, 1979; Khan and Law, 2005; Stehr *et al.*, 2009).

A unique characteristic of peat swamp forest is that it forms a very important habitat for diverse fish assemblages. Some fishes are endemic to its black and highly acidic water, which is why a proper study on water properties of peat swamp ecosystem is very important. An intensive survey of part of North Selangor peat swamp forest recorded 47 species. This represents about 20% of the total known ichthyofauna in Peninsular Malaysia, of which 14 species are probably stenotopic taxa (Ng *et al.*, 1994a). It was estimated that the total number of species in Peninsular Malaysia, Borneo and Sumatra peat swamps may reach 300 species (Dennis and Aldhous, 2004).

Ikusima *et al.* (1982) has described the physical and chemical properties of Tasek Bera. The data were collected from 1970 to 1974 during the Tasek Bera scientific expedition which involved only Pos Iskandar, situated in the southwestern part of the lake. Any changes or decreases of water quality through time could affect the existence of fish. A small tropical reservoir, Chenderoh Reservoir on the Perak River has gone through a reduction in biodiversity of fish species after environmental perturbation caused by land-use activities (Ali, 2006). Shah *et al.* (2006) concluded the fish biodiversity and composition of the Paya Beriah Peat Swamp Forest have changed rapidly and some endemic species have gone extinct or extinct locally due to the development of that swamp area. A study of the water quality changes in Tasek Chini, situated southeast of Pahang and the nearest wetland to Tasek Bera by Shuhaimi-Othman *et al.*(2007) placed the lake in class II according to The Malaysian Water Quality Index (DOE-WQI). Water classified in Class II need to undergo conventional treatment before it can be used as water supply and is suitable only for aquatic species which have high tolerance to harsh environment.

Zakaria *et al.* (1999) conducted a comparative study between the freshwater swamp at Beriah Kanan and the peat swamp area at Ulu Sedili Rivers. They discovered that both sites had similar pH, conductivity and ammonium levels, but Ulu Sedili River showed relatively higher orthophosphate, hardness and total suspended solids. This was due to destruction of the peat swamp ecosystem, and subsequent lowering the number of fish species living in the river. Johnson (1967a), in his studies on the chemistry of freshwaters in southern Peninsular Malaysia and Singapore included black water habitats in Malacca and Johor. He believed that the chemical characteristics of the waters are important in determining the distributional pattern of fish for those two areas that have relatively high salinity, low pH, high excess sulphate, very high magnesium and low oxygen.

This chapter describes the selected physical and chemical characteristics of the lake collected over a period of one and a half years (from May 2004 to December 2005) from the 11 study sites in Tasek Bera, which is important to determine the influence of water quality on fish distribution.

2.2 MATERIALS AND METHODS

2.2.1 Sampling Site

Eleven locations (Fig. 2.1) were selected for water quality sampling. Description of these locations is given in the Table 2.1 which includes the GPS reading for each location.

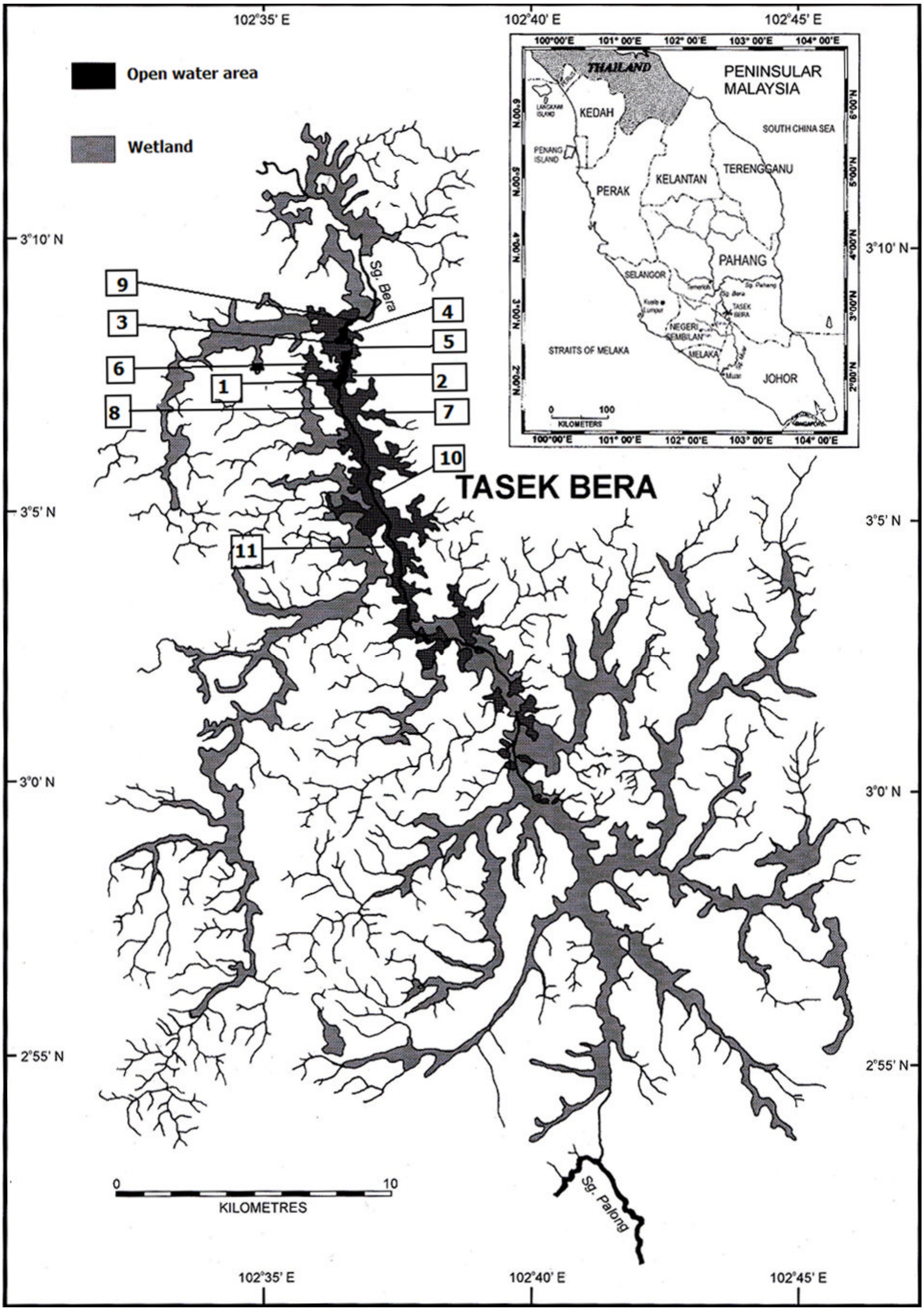


Figure 2.1 Location of water quality sampling sites in Tasek Bera

Table 2.1 Description of water quality sampling sites in Tasek Bera.

Site no.	Location and description	GPS coordinates
1	Lubuk Kuin (beside the Perhilitan's jetty) – Limnetic section. Open water and main body of the lake at the vicinity of Lubuk Kuin. The site of the bank growth with *Pandanus* stand. Depth range from 2 to 3 m. Water flow very minimal.	03^0 07.692'N; 102^0 36.381'E
2	Lubuk Kuin (across the Perhilitan's jetty) - Sublittoral section. Open water and main body of the lake at the vicinity of Lubuk Kuin. The site of the bank growth with *Pandanus* stand and *Lepironia* reed. Depth range from 2 to 3 m. Water flow very minimal.	03^0 07.755'N, 102^0 36.359'E
3	Lubuk Sanglar - Sublittotal section. Open water close to the main channel flowing out towards Tasek River. Depth range from 1.5 to 3 m. Water flow very swift. Surrounded with *Pandanus* stand.	03^0 08.421'N, 102^0 36.354'E
4	Tanjung Bahau - Sublittoral section. Open water close to the main channel flowing out towards Sg. Tasek. Depth range from 1.5 to 3 m. Water flow very swift. Surrounded with *Pandanus* stand.	03^0 08.317'N, 102^0 36.400'E
5	Tanjung Penarikan – Limnetic section. Open water and shallow part of Tasek Bera at the vicinity of Lubuk Kuin surrounded with *Pandanus* stand. Maximum depth can reach up to 2 m.	03^0 08.297'N, 102^0 36.500'E
6	Lubuk Salleh - Littoral section. Main channel through thick cover of *Pandanus* stand. The deepest areas that water can reach up to 10 m in rainy season. Water flow minimal.	03^0 08.224'N, 102^0 36.396'E
7	Teluk Gedubang - Limnetic section. Open water at the vicinity of Lubuk Kuin. Substrate consists of sand at some area. Surrounded with *Pandanus* stand. Often exposed in dry season. Maximum depth can reach up to 2 m.	03^0 07.353'N, 102^0 37.341'E
8	Teluk Keminyan - Limnetic section. Shallow part of Tasek Bera at the vicinity of Lubuk Kuin surrounded with *Lepironia* reed. Often dries up most of the time. Maximum depth up to 2 m.	03^0 08.297'N, 102^0 36.270'E
9	Lubuk Ranting Patah - Limnetic section. Part of Tasek River swamp areas with 50% canopy cover. Substrate mainly, mud, submerged log, detritus and decomposing leaves. Water flow slowly into Bera River.	03^0 08.560'N, 102^0 36.647'E
10	Lubuk Chenderong - Littoral section. Main channel of Tasek Bera near Lubuk Chenderong. Water flow is slightly faster. Depth range from 3 to 6 m.	03^0 05.540'N, 102^0 36.883'E
11	Lubuk Benal - Sublittoral section. Open waters near Lubuk Benal. Vegetation consists of *Pandanus* stand and *Lepironia* reed.Water flow minimal.	03^0 04.752'N, 102^0 37.179'E

2.2.2 Rainfall Data Collection

Rainfall data for the Tasek Bera were obtained from the Malaysian Hydrology and Water Resources Department which collected the data at Kg. Kuala Bera, Pahang as representative for the study site. Kampung Kuala Bera is located about 30 km from Pos Iskandar. Rainfall data was collected for the duration of the water parameter sampling efforts (2004-2005).

2.2.3 Measurement of Water Quality Parameters

Physical and chemical parameters measured were temperature (^{0}C), total suspended solids (TSS mg/L), turbidity (in Nephelometric unit, NTU), pH, conductivity (µS/cm), total dissolved solids (TDS in mg/L), hydrogen sulphide (H_2S in µg/L), ammonium (NH_4^+ in µg/L), ammonia (NH_3 in µg/L), nitrite (NO_2^- in µg/L) and dissolved oxygen (DO in mg/L). A YSI multiparameter sonde model 6000 UPG was used for measuring turbidity, pH, conductivity, TDS and DO. Determination of H_2S, NH_4^+ and NO_2^- were carried out in the field immediately after the water sample was brought back to the base camp by using a portable MERCK photometer. Ammonia was estimated from the concentration of ammonium ions (NH_4^+) at different pH values and temperatures, following the procedure as suggested by Emerson *et al.*(1975). The total suspended solid (TSS) was determined following the standard procedure by the Standard Methods (APHA, 1992). A measuring tape was used to measure depth at the sampling sites. The GPS reading of the sites was determined using a Magellan GPS instrument model NAV 5000DLX.

All *in-situ* readings and water samples were collected on three different sampling occasion at each of the sampling site, rotated among the 11 sites during monthly sampling efforts from April 2004 to December 2005. On each sampling occasion, readings were taken at every metre from the surface to the bottom of each station, at three different time intervals (0600, 1400 and 2200 hours).

2.3 RESULTS

2.3.1 Rainfall Data

The monthly average daily rainfall was 3.86 mm in 2004 and 4.25 mm in 2005 (Fig. 2.2), calculated from daily rainfall data (Appendix 1 & 2). The total monthly rainfall in 2004 showed that the lowest rainfall was in February (6 mm) and reached the highest precipitation in October (270 mm). Total rainfall in 2005 was lowest in January but increased toward the end of the year (Fig. 2.2). In December 2005, the total rainfall was highest, exceeding 350 mm. The increased rainfall for both years from September to December corresponded to the Northeast monsoon. The annual total rainfall for 2004 and 2005 were 1407.5 mm and 1551.0 mm respectively.

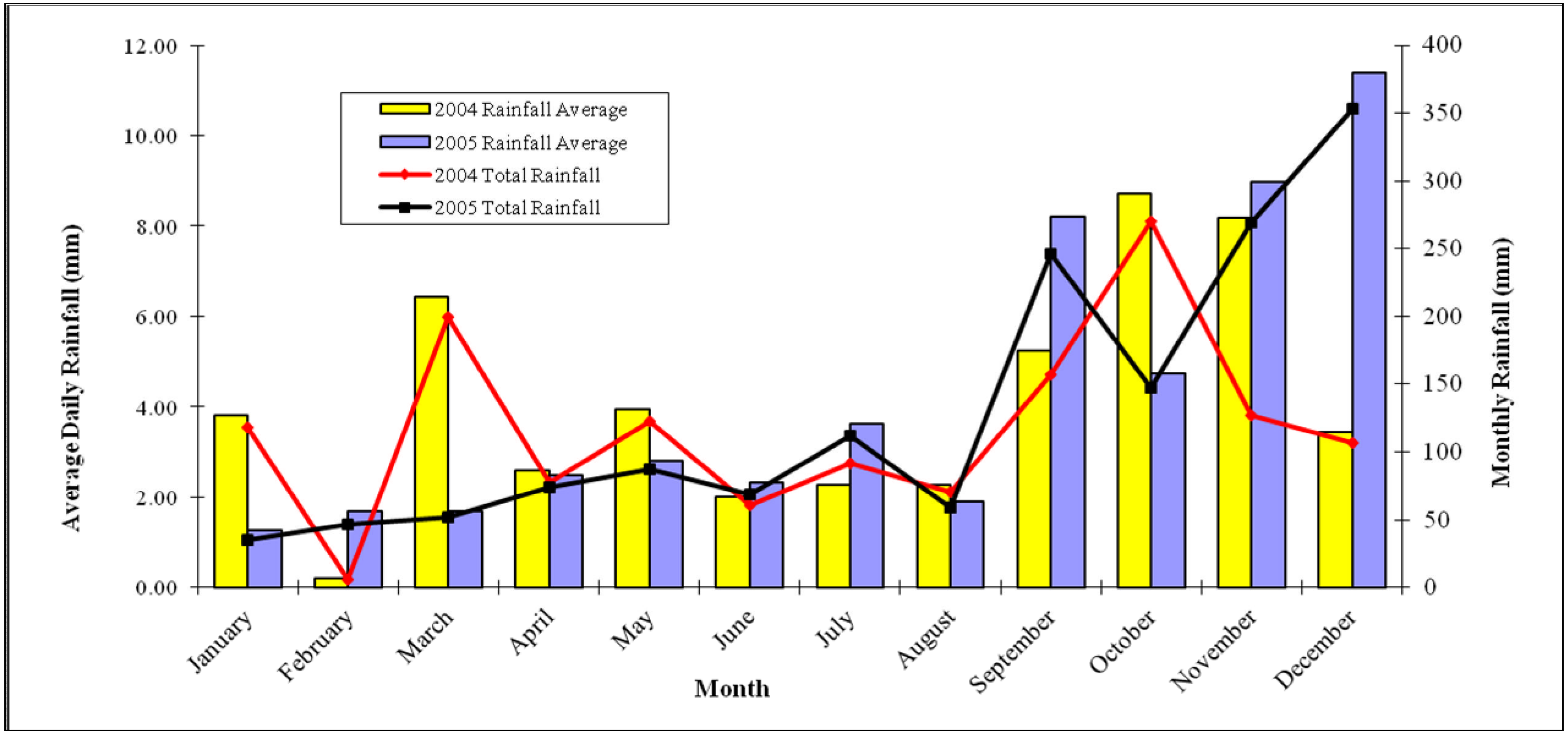


Figure 2.2 Average and total rainfall for each month at Tasek Bera (2004 and 2005) measured at Kg. Kuala Bera. Rainfall data were obtained from the Malaysia Hydrology and Water Resources Department, Malaysia.

2.3.2 Water Temperature

The average water temperature of the 11 sampling sites ranged from 27.37^0C to 30.31^0C and the variation is significant (Table 2.2, $p<0.05$). Higher temperatures were observed in the open water sites (examples Tanjung Bahau and Teluk Keminyan) while lower values were recorded at the forested regions which were sheltered from solar radiation by the canopy of *Pandanus* stands and secondary forest such as at Lubuk Chenderong and Lubuk Benal (Table 2.1).

Water temperature was significantly higher at the surface compared to the bottom layers ($p<0.05$). It ranged from 26.25 ^{0}C to 32.07 ^{0}C at the surface and 26.77 ^{0}C to 28.95^0C at bottom layers (Fig. 2.3). The higher temperature differential of the surface waters may be due to direct absorption of solar irradiance (the greatest source of heat) during the day. Mogollon *et al.* (1996) reported water temperature of Lake Valencia (tropical lowland lake in Venezuela) declined with depth (1^0C every 25 m depth) from approximately 26^0C.

Mean temperatures among the 0600, 1400 and 2200 hours sampling times were significantly different ($p<0.05$). The highest reading was obtained at 2200 while the lowest one was at 0600 hours (Fig. 2.4). The peak temperature reading at night was likely due to lingering effects of the solar radiation which usually remains high past the mid-day sampling time of 1400 hours. However, riparian vegetation intercepts direct solar radiation and therefore plays an important role in reducing maximum temperature in sheltered sites. At night, back radiation by this vegetation can reduce heat loss from the surface of the lake, maintaining relatively warm minimum temperatures. Detailed information of the number of replicates, maximum, minimum and mean values at each sampling depth and intervals are provided in Appendix 3 and Appendix 4.

Table 2.2 Mean and standard deviation (±) of selected physical parameters measured at Tasek Bera during the study period from April 2004 to December 2005. The parameters were recorded at the interval of 3 times in a day (0600, 1400 and 2200 hours) and at every metre depth interval. The symbol ND refers to non-detectable data.

Site sampling	Physical parameter		
	Temperature (^{0}C)	Total Suspended Solids (mg/L)	Turbidity (NTU)
Lubuk Kuin (beside Perhilitan jetty)	29.76 ± 0.78	9.51 ± 8.38	7.14 ± 2.21
Lubuk Kuin (opposite Perhilitan jetty)	28.81 ± 1.56	14.79 ± 21.58	4.20 ± 1.19
Lubuk Sanglar	30.01 ± 1.19	9.00 ± 15.01	4.02 ± 1.35
Tanjung Bahau	30.31 ± 0.96	36.64 ± 51.43	6.90 ± 1.54
Tanjung Penarikan	29.35 ± 0.89	11.03 ± 17.45	5.55 ± 1.12
Lubuk Salleh	28.90 ± 0.53	44.91 ± 36.14	7.73 ± 1.48
Teluk Gedubang	30.16 ± 0.65	22.52 ± 14.72	9.82 ± 3.72
Teluk Keminyan	30.21.± 0.53	12.51 ± 12.74	8.16 ± 1.71
Lubuk Ranting Patah	29.38 ± 0.64	6.70 ± 2.08	8.43 ± 2.73
Lubuk Chenderong	27.60 ± 0.74	7.35 ± 7.91	20.49 ± 10.41
Lubuk Benal	27.37 ± 0.79	3.27 ± 3.38	12.22 ± 4.76

In the present study, water temperature showed a minimum of 26.25^0C in December 2005 at the surface areas of Lubuk Benal, which is one of the littoral sections of Tasek Bera and the reading was taken at 0600 hours. It is one of the main channels for water flowing into Bera River and is surrounded by secondary forest and *Pandanus* clumps. According to rainfall data in 2005 (Fig. 2.2), the month of December was indicated as the wet season brought about by the Northeast monsoon. This explains the low temperature that month. The maximum temperature at the surface taken at 2200 was 32.07^0C in May 2005. The temperature was higher this month as it was the dry season. Shuhaimi-Othman *et al.* (2007) reported temperature of Chini Lake ranged from 25.44^0C to 32.19^0C and has a significant negative relationship with the rainfall, meanwhile Yule and Gomez (2009) and Shuhaimi-Othman *et al.* (2009) reported a temperature range from 24.7^0C to 32.0^0C for North Selangor Peat Swamp Forest Reserve and 26.08^0C to 29.99^0C for Bebar Peat swamp forest repectively, which is almost similar to those of the present study of Tasek Bera. Zakaria *et al.*(1999) reported that temperatures for Ulu Sedili and Beriah Kanan, both freshwater swamps in Peninsular Malaysia, ranged from 24.30^0C to 25.50^0C respectively. Historically, Lim and Furtado (1982) reported overall mean temperature of Tasek Bera ranged from an average 26.3^0C at the surface (minimum 23.3^0C and maximum 31.2^0C) and 25.4^0C at the bottom (minimum of 23.3^0C to a maximum of 26.6^0C). In 2002, Sim reported the temperature for Tasek Bera ranged from 25.86^0C to 31.0^0C. Both years showed lower reading than the present study of Tasek Bera (Table 2.3).

Table 2.3 Comparison of Tasek Bera water quality between Furtado and Mori (1982), Sim (2002) and present study (2004-2005)

Parameters		**Furtado & Mori (1982)**	**Sim (2002)**	**Present (2004 -2005)**
Temperature (^oC)	Mean	26.3	-	29.54
	Min	23.2	25.86	26.25
	Max	31.2	31.0	32.07
Total Suspended Solids (mg/L)	Mean	-	-	19.38
	Min	-	-	1.00
	Max	-	-	188.00
Turbidity (NTU)	Mean	-	-	8.03
	Min	-	5.3	2.50
	Max	-	10.7	29.90
Total Dissolved solid (mg/L)	Mean	-	-	31.64
	Min	-	-	23.00
	Max	-	-	56.00
Conductivity (microS)	Mean	14.2	-	44.85
	Min	10.5	18.0	35.00
	Max	23.0	39.4	58.00
Dissolved Oxygen (mg/L)	Mean	2.09	-	3.66
	Min	0.84	0.23	0.93
	Max	9.02	5.05	6.22
pH	Mean	5.33	-	5.77
	Min	4.57	4.03	4.14
	Max	6.83	6.87	8.60
Hydrogen sulphide (µg/L)	Mean	-	-	1.11
	Min	-	-	Undetectable
	Max	-	-	10.00
Nitrite (µg/L)	Mean	7.4	-	4.63
	Min	0.0	-	0.00
	Max	59.0	-	100.00
Ammonium (µg/L)	Mean	390.0	Undetectable	67.80
	Min	193.0	-	0.00
	Max	767.0	-	350.00
Ammonia (µg/L)	Mean	-	-	0.38
	Min	-	-	0.000
	Max	-	-	1.87

Factors that affect water temperature change include weather, removal of bank vegetation, discharge of cooling water, and runoff water. LeBlanc *et al.* (1997) discovered that shade of riparian vegetation, groundwater discharge, and stream width had the greatest influence on stream temperature. Tropical lakes are usually warm polymictic (showing minimal thermal stratification) bodies that exhibit frequent periods of circulation at temperatures above 4^0C. Annual temperature variations are small in equatorial tropics and there are repeated periods of circulation between short intervals of heating and weak stratification, followed by periods of rapid cooling (Wetzel, 2001). The temperature of Temenggor Lake with a depth of up to 100 m, showed a clinograde curve where readings were higher at the surface and lower at the bottom (Zakaria-Ismail and Sabariah, 1995). For Tasek Bera, stratification was very weak due to the shallowness of the water, but exhibited diel variations because of the exposure to direct solar irradiance during the day. Some parts of the lake have vegetation cover. Submerged aquatic vegetation tends to alter annual mean temperature. Imberger (1985) defined the surface layer as the region of the upper mixed layer directly affected by wind force and surface heating. It is actively mixing at the surface, whereas the water below may not be. Bartholow (1989) found that air temperature above the surface of the water; relative humidity and shade are factors increasing water temperatures of the surface water. Verburg *et al.* (2003) reported the Lake Tanganyika recorded a century-long warming trend, for example, north basin temperatures have increased since 1913 by 0.2^0C near the bottom and by 0.9^0C at 100 m depth. O'Reilly *et al.* (2003) found the increased of air temperature above Lake Tanganyika was proportional to water temperature. Idris and Abas (2005) have looked at the deterioration in some physical aspects of water quality trends of the Tasek Chini (in 1992, 1993 and 1998) and discovered an increase in temperature by about 2^0C. Vollmer *et al.* (2005) proposed cool river water inflow and heavy rainfall as a source of cooler water which subsequently also control thermal structure and rate of deep-water recharge in Lake Malawi. This condition happens in Lake Tanganyika and also other lakes ecosystems that have inflowing river water as in Tasek Bera and Tasek Chini.

2.3.3 Total Suspended Solids (TSS) and Turbidity

Most suspended solids come from accelerated erosion from agricultural land, logging operations (especially where clear-cutting is practiced), surface mining, and construction sites. Suspended solids consist of an inorganic fraction (silts, clays, and other soil constituents), an organic fraction (algae, zooplankton, bacteria and detritus), bits of decaying vegetation, industrial wastes and sewage that are carried along by water as it runs off the land, which contribute to turbidity, or cloudiness of the water (Wetzel, 2001). For Tasek Bera, the water is darkly stained from dissolved organic material coming from peat, which additionally contributes to decreased clarity. Tannins, humic acid, and humate from the decomposition of lignin are the principal colouring matter. Packman *et al.* (1999) and Yusoff *et al.* (2006) showed strong positive correlation between TSS and turbidity. Turbidity is the measure of light scattering properties of water.

Average values of the total suspended solids (TSS) from the 11 sites ranged from 3.27 mg/L to 44.91 mg/L; the lowest being recorded at Lubuk Benal and the highest at Lubuk Salleh (Table 2.2). The Putrajaya Wetlands in Malaysia, a constructed wetland system consisting of 24 cells, showed TSS ranged from 7.2 mg/L to 137.5 mg/L, which was much higher than Tasek Bera (Sim *et al*., 2008). The TSS of the Lake Malawi, one of the largest lakes in the world, with maximum depth that can reach up to 700 m, was between 0.1 and 0.5 mg/L. The sources could be from biological productivity at the surface, chemical or biological processes at the chemocline, and resuspension events because of the waves and currents (Halfman and Scholz, 1993).

Sharifah *et al.* (2003) and Lin *et al.* (2008) reported that rainfall was significantly correlated with the quantity of soil erosion in the Tekala River catchment in Selangor and Changhua and Yunlin Counties in Taiwan respectively.

The readings of TSS were significantly different ($p<0.05$) among the stations during the study period. High TSS reading at Lubuk Salleh was probably due to it being the major channel system flowing through the system. The depth in this area can reach up to 10 m during rainy seasons, when water flow increase erosion and deposition of suspended solids in the water column. However, the highest TSS reading was taken in May 2005, which was not during the wet season. Total suspended solids profile shows the maximum reading at depth of 5 to 6 m (Fig. 2.3). The minimum reading recorded at the surface was probably due to slow movement of the water resulting in the sinking of the particles. The TSS varied significantly among depths ($p<0.05$). Zakaria-Ismail and Sabariah (1995) reported the same increment of TSS in Temenggor Lake. Halfman and Scholz (1993) believed that this situation was caused by the accumulation of material from above and/or the suspension of sediment from the lake floor by large surface waves, surface currents, or seiche (water oscillation brought about by physical disturbance such as atmospheric changes or seismic activity). Temporally, the mean for TSS did not differ significantly between 0600, 1400 and 2200 hours (Fig. 2.4) although the highest value of 23.0 mg/L was recorded at 2200 hours (Appendix 4).

Riparian areas with dense vegetation and slow meandering streams typically are responsible for the low suspended solids concentration (Pollard, 2006). Indirectly, the TSS affects other parameters such as temperature, dissolved oxygen and nutrients such as phosphorus. Because of the greater heat absorbency of the particulate matter, the surface water becomes warmer and this tends to stabilise the stratification in the lake. This, in turn, interferes with mixing, decreasing the dispersion of oxygen and nutrients to deeper layers.

The mean turbidity at the 11 sites ranged from 4.02 to 20.49 NTU (Table 2.2). The minimum value was recorded at Lubuk Sanglar and the maximum reading was found at Lubuk Chenderong. The water moved a bit faster at Lubuk Chenderong, which is one of the major channel systems surrounded by secondary forests. The removal of riparian vegetation and bank disturbances could be the reason why the turbidity reading was higher at this site as strongly suggested by Maillard and Santos (2008). Shuhaimi-Othman *et al.* (2009) reported the turbidity reading for Bebar peat swamp range from 0 to 9.47 NTU.

The mean turbidity among depths was significantly different ($p<0.05$). Surface areas (between 0 to 1 m) show the lowest readings for turbidity due to direct penetration by sunlight. However, at 1 to 2 m, the turbidity was highest (average of 8.7 NTU) and declining with depth (Fig. 2.3).

Higher turbidity was observed during night compared to day time (Fig. 2.4). Turbidity was significantly different ($p<0.05$). Gillain (2005) found that the dial turbidity fluctuations are represented by elevated turbidity values that occur near sunrise, followed by a decrease throughout the day, with lowest values occurring near sun-set, and evening values show a gradual increase through the night to sunrise. She concluded several mechanisms for turbidity variation including instrumentation effects, sediment transport, and biological activity. Coincidence of turbidity and dissolved oxygen fluctuations supports biological activity as a cause of dial turbidity fluctuations.

Previously, turbidity was recorded between 5.3 to 10.7 NTU by Sim (2002) which was lower than present data (Table 2.3). Higher turbidity increases water temperatures because the suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen because warm water holds less dissolved oxygen than cold water. It also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of dissolved oxygen (EPA, 1997).

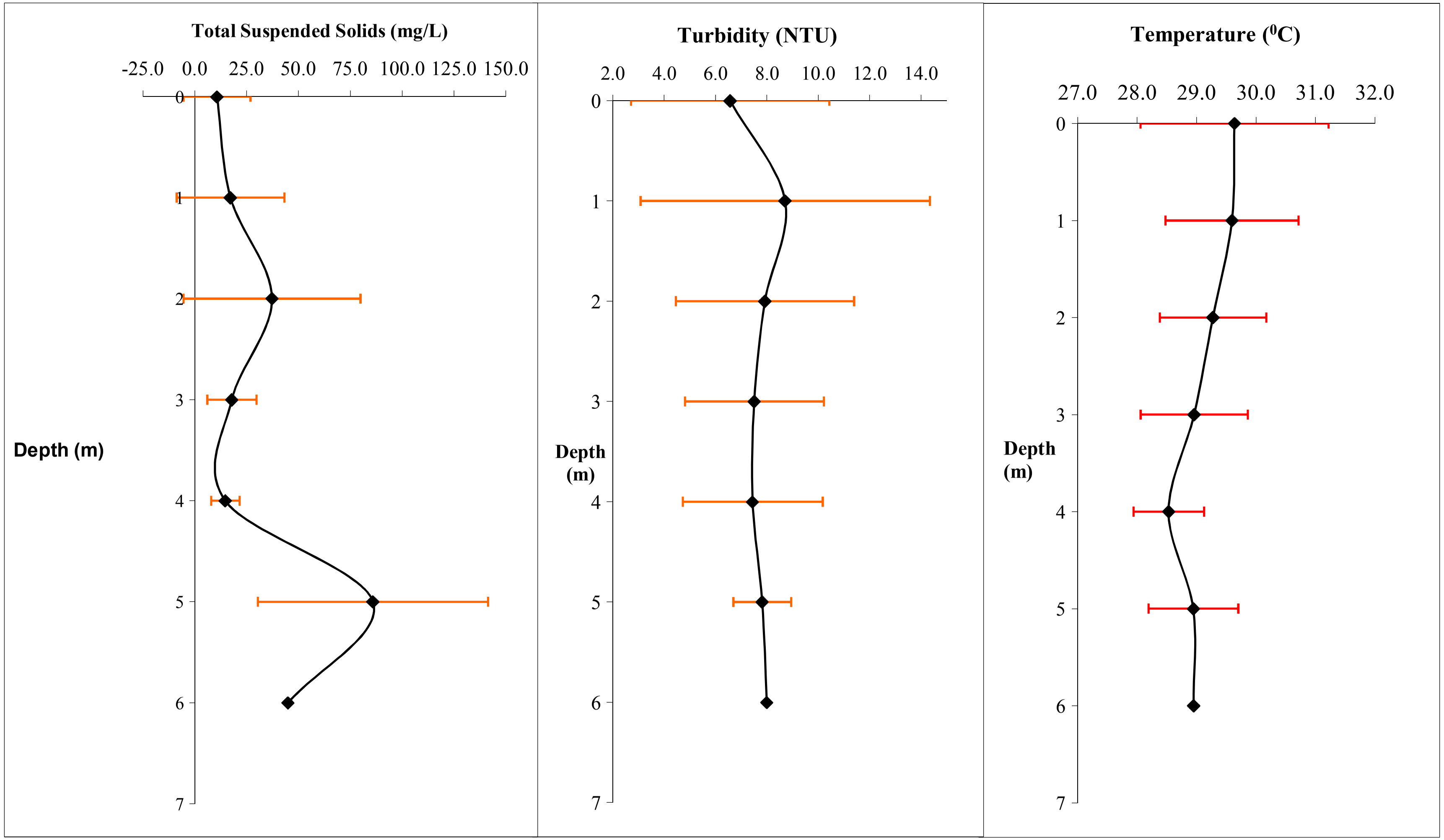


Figure 2.3 Depth profile of temperature (^{0}C), turbidity (NTU) and total suspended solids (mg/L) measured at 11 sampling sites in Tasek Bera. Error bar indicate standard deviation.

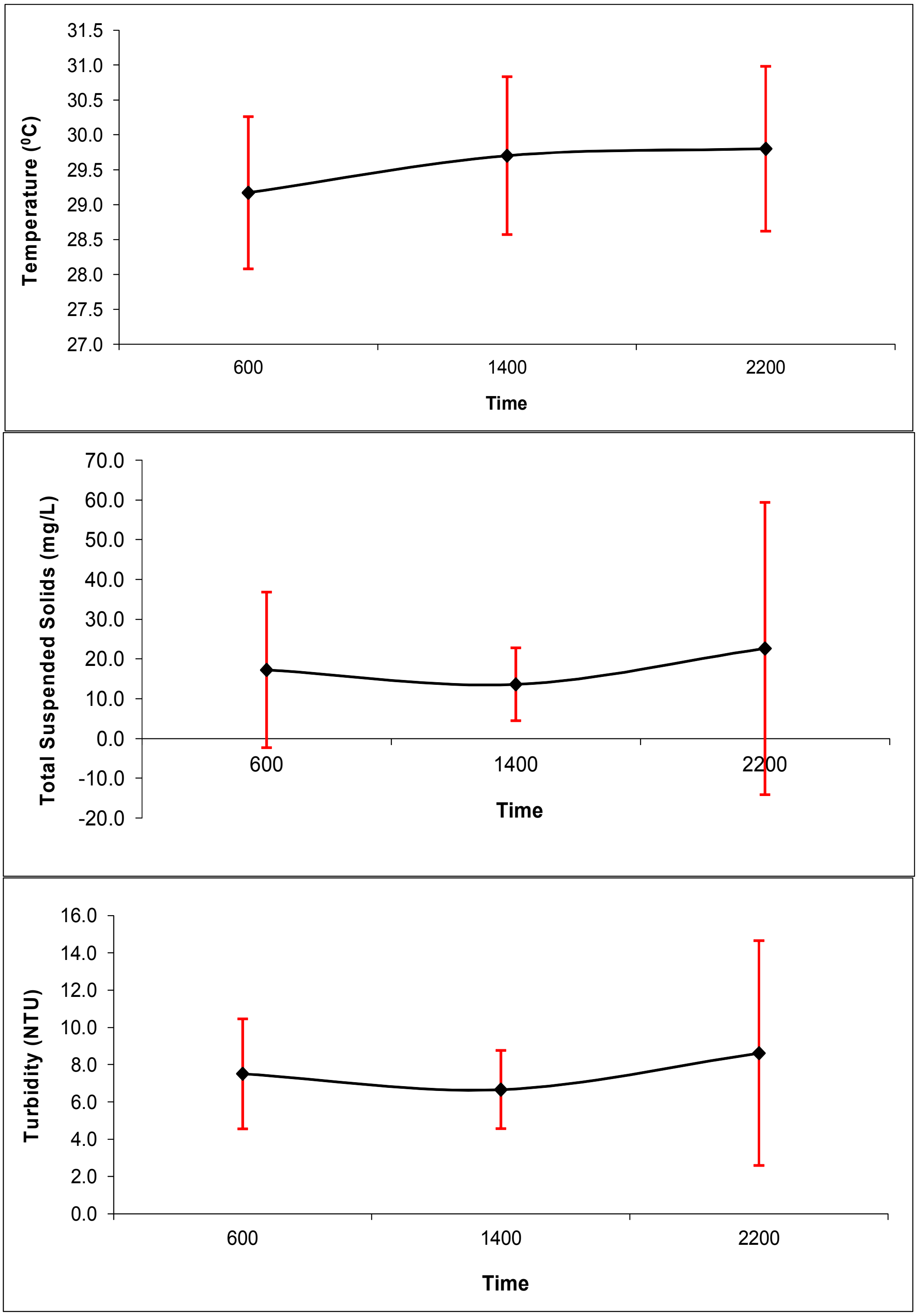


Figure 2.4 Mean of temperature (^{0}C), total suspended solids (mg/L) and turbidity (NTU) at 0600, 1400 and 2200 hours. Error bar indicate standard deviation.

2.3.4 Total Dissolved Solids

Total dissolved solids are defined as materials in water that will pass through a filter with a pore size of 2 μm or smaller (APHA, 1992). Most of the dissolved matter in fresh waters consists of inorganic salts, small amounts of organic matter, and dissolved gasses (Sawyer *et al*., 2003). Water that have high concentrations of TDS may have objectionable tastes or cause adverse physiological effects when consumed by humans and livestock.

The total dissolved solids in the Tasek Bera varied from 27.98 to 35.07 mg/L. The minimum was recorded at Lubuk Salleh and the maximum at Lubuk Kuin (opposite Perhilitan's jetty) (Table 2.4). The means differed significantly among sites ($p<0.05$). This may be due to the hydrographic contrast between fast running and slow flowing, partially stagnant water as shown by Mwaura (2006). He also discovered that some areas with hotter and drier condition caused high evaporative concentration effect and showed higher reading of TDS. The highest readings of 56.00 and 47.00 mg/L were taken in June 2004 and February 2004, respectively and both months were in dry seasons. The range of TDS in Tasek Bera was quite low compared to Tasek Chini (Gasim *et al.,* 2006a; Shuhaimi-Othman and Lim, 2006) and Putrajaya Wetlands in Malaysia (Sim *et al*., 2008) but was similar to Bebar peat swamp (Shuhaimi-Othman *et al*., 2009). North Selangor Peat Swamp Forest Reserve (NSPSF) as reported by Yule and Gomez (2009) showed much higher reading, ranging from 89.00 mg/L to 134.00 mg/L. The differences are probably associated with environmental factors such as catchments geology, vegetation cover, climate, and runoff quality. The influence of land use also varies from one area to another.

Higher TDS was determined at 4 to 5 m and lowest was at 1 to 2 m from the surface (Fig. 2.5) and the values varied ($p<0.05$) between depths. Bottom areas of waters had higher TDS than surface waters. These ions were probably released by decomposition processes and trapped in the lower layers during the day because of thermal stratification, and thus gave rise to chemical stratification. Oxygen was low at mid-depth during the evening, and it seems assured that it was low in the bottom waters for part of the day. These deoxygenated waters would have had a low redox potential favoring the release of certain ions from bottom sediment (Hutchinson, 1957).

Mean values of TDS according to time shows no significant difference (Fig. 2.6), only at 1400 the reading was a bit higher. This may be due to high evaporation that happened at that time. Detailed information of the number of replicates, maximum, minimum and mean values at each sampling depth and intervals are provided in Appendix 3 and Appendix 4.

Table 2.4 Mean and standard deviation (±) of chemical parameters measured at Tasek Bera during the study period from April 2004 to December 2005. The parameters were recorded at the interval of 3 times (0600, 1400 and 2200) hours in a day and at every metre depth interval. The symbols ND refer to non-detectable data. The ammonia was estimated from the concentration of ammonium ions (Emerson *et al.,* 1975).

	Total Dissolved Solids (mg/L)	Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	pH	Hydrogen Sulphide (µg/L)	Nitrite (µg/L)	Ammonium (µg/L)	Ammonia (µg/L)
Lubuk Kuin (beside Perhilitan jetty)	30.36 ± 7.95	42.62 ± 5.13	3.48 ± 0.57	5.72 ± 1.12	ND	1.29 ± 4.99	78.39 ± 46.98	0.470 ± 0.390
Lubuk Kuin (opposite Perhilitan jetty)	35.07± 4.14	49.93 ± 5.95	3.88 ± 1.37	5.16 ± 1.20	5.00 ± 5.48	3.33 ± 5.16	11.67 ± 18.35	0.0042 ± 0.0123
Lubuk Sanglar	32.27 ± 2.44	49.10 ± 1.99	2.99 ± 0.97	5.04 ± 1.09	ND	ND	10.00 ± 0.00	0.081 ± 0.000
Tanjung Bahau	32.49 ± 1.89	47.18 ± 4.01	5.25 ± 0.96	6.46 ± 1.07	0.67 ± 2.52	2.22 ± 4.20	36.44 ± 41.95	0.131 ± 0.181
Tanjung Penarikan	32.51 ± 3.59	44.19 ± 3.30	4.85 ± 0.92	6.72 ± 1.05	3.24 ± 4.75	3.78 ± 4.92	31.08 ± 27.57	0.165 ± 0.090
Lubuk Salleh	34.93 ± 4.50	42.25 ± 5.46	3.86 ± 0.91	6.30 ± 1.05	0.88 ± 2.86	7.79 ± 16.91	69.56 ± 47.66	0.320 ± 0.300
Teluk Gedubang	27.98 ± 3.87	42.55 ± 5.74	3.97 ± 1.39	5.46 ± 1.13	0.45 ± 2.11	5.00 ± 6.99	123.41 ± 110.87	0.705 ± 0.630
Teluk Keminyan	28.15 ± 3.91	43.38 ± 5.78	3.47 ± 0.68	5.50 ± 1.12	0.28 ± 1.67	1.39 ± 3.51	112.22 ± 35.14	0.911 ± 0.290
Lubuk Ranting Patah	34.00 ± 2.83	44.74 ± 6.33	2.98 ± 0.59	5.36 ± 1.12	ND	9.09 ± 3.02	84.55 ± 54.66	0.061 ± 0.40
Lubuk Chenderong	32.70 ± 2.18	49.45 ± 4.74	2.02 ± 1.22	5.27 ± 1.07	3.75 ± 5.17	11.25 ± 6.41	7.50 ± 13.89	0.005 ± 0.009
Lubuk Benal	33.05 ± 6.69	46.41 ± 8.26	2.07 ± 1.10	5.00 ± 1.09	7.50 ± 5.00	20.00 ± 11.55	30.00 ± 38.30	0.020 ± 0.025

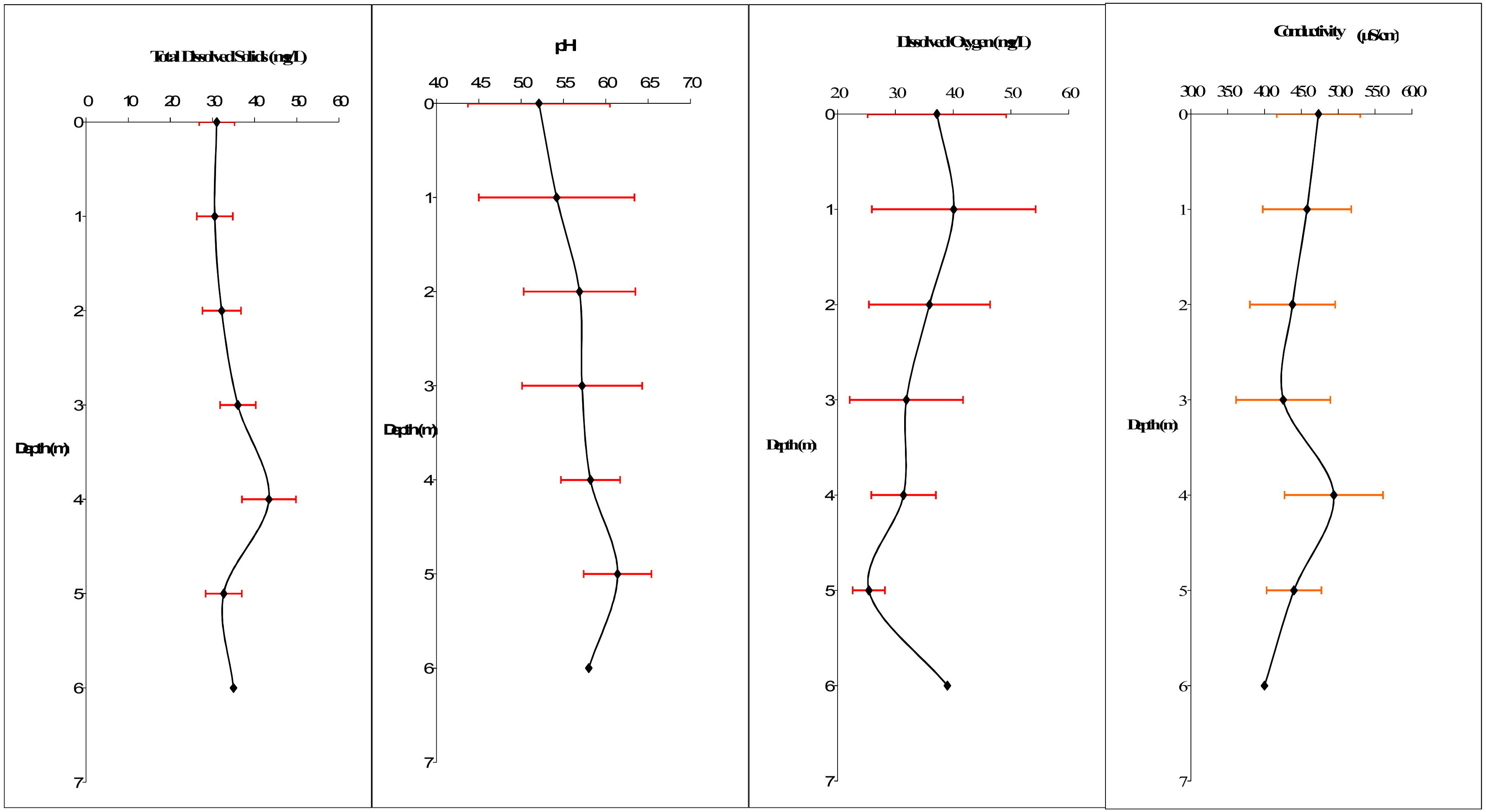


Figure 2.5 Depth profile of total dissolved solids (mg/l), pH, dissolved oxygen (mg/L) and conductivity (µS/cm) measured at 11 sampling sites in Tasek Bera. Error bar indicate standard deviation.

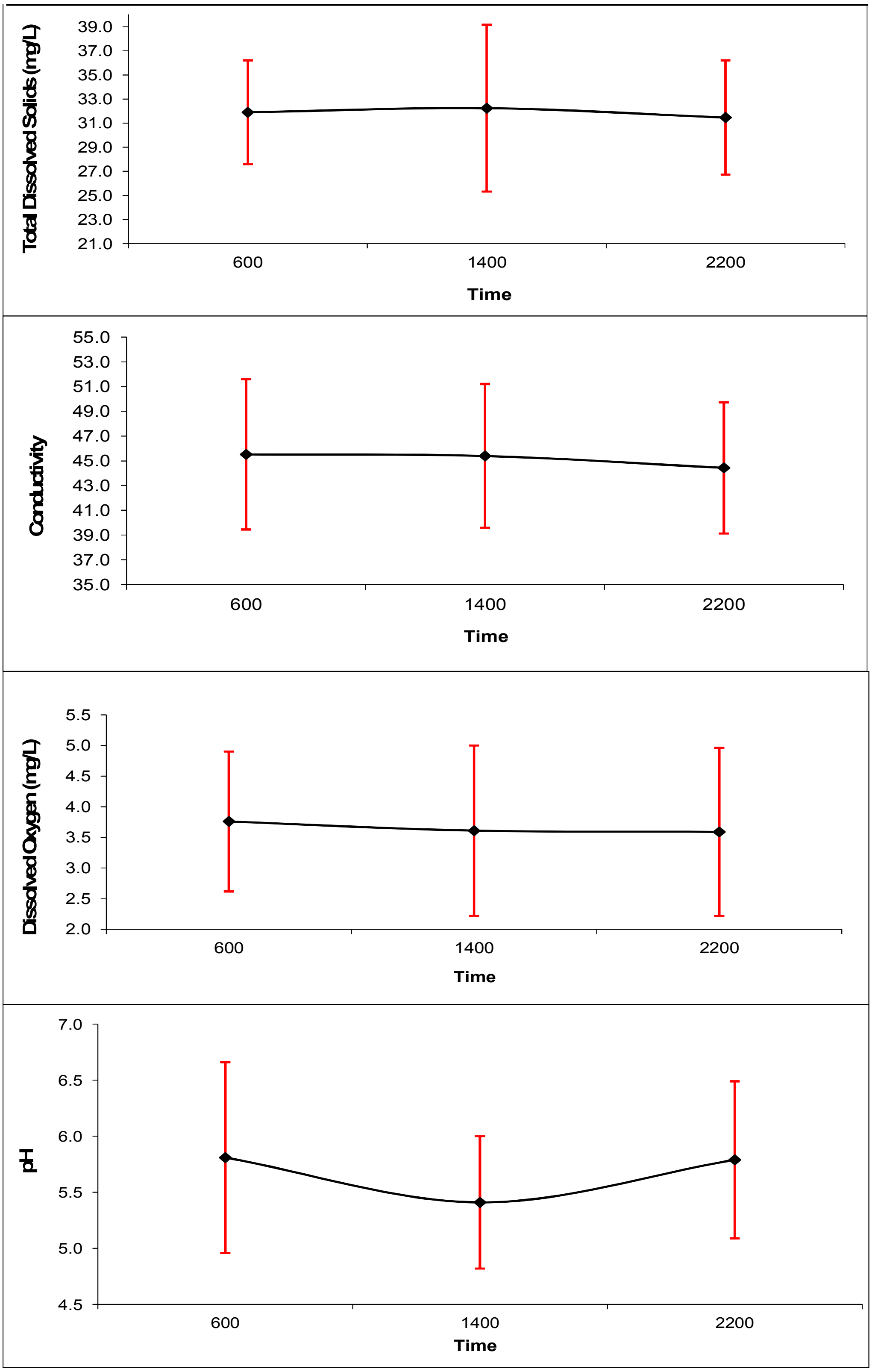


Figure 2.6 Means of total dissolved solids (mg/L), conductivity (µg/L), dissolved oxygen (mg/L) and pH at 0600, 1400 and 2200. Error bar indicate standard deviation.

2.3.5 Conductivity

Conductivity is a measure of water's ability to conduct an electric current and is directly related to the total dissolved salts (ions) in the water. Some pollution discharges and polluted runoff into lakes can cause changes in conductivity especially if the pollutants include inorganic dissolved solids such as ions: bicarbonate, sulphate, chloride, calcium, magnesium, sodium, potassium, and phosphate. Called EC for electrical conductivity and historically reported in micromhos per centimetre (µmhos/cm), this parameter has been recently renamed as uS/cm (microSiemens per centimetre). EC is temperature sensitive and increases with increasing temperature. Most modern probes automatically correct for temperature and standardise all readings to 25°C and then refer to the data as *specific* EC.

The average conductivity reading from 11 sites ranged from 42.25 uS/cm to 49.93 uS/cm (Table 2.4). There was significant difference among sites ($p<0.05$). Lubuk Kuin (opposite Perhilitan's jetty), Lubuk Sanglar and Lubuk Ranting Patah showed higher readings than the others.

The value of conductivity at depth 4 to 5 m from the surface shows the highest values reaching 50.00 µS/cm (Appendix 3). The means were significantly different among depths ($p<0.05$). However, there was no significant difference between the three sampling times. The graph shows that conductivity was slightly reduced at night (Fig. 2.6).

Lim and Furtado (1982) reported conductivity of Tasek Bera range from 10.5 to 23.0 umhos/cm, which was two times lower than present values. Sim (2002) recorded range from 18.0 to 39.4 umhos/cm for Tasek Bera which was also lower than present data (Table 2.3). Values reported by Gasim *et al.* (2006) and Shuhaimi-Othman *et al.* (2007) of Tasek Chini ranged from 14.33 to 85.7 µS/cm and 14.98 to 50.83 µS/cm, respectively, compared with Putrajaya Wetlands which ranged from 54.8 to 146.3

μS/cm (Sim *et al.,* 2008). Average conductivity of Kyoga Lake in Uganda, which has depths up to 3.6 m and consists of swamp and marsh land, ranged from 106.0 to 168.0 μS/cm (Mungoma, 1988). All of these wetlands have been polluted by human activities especially from agricultural activities and human household wastes which are brought into the water body by runoff, particularly during rainy seasons. According to Carrino-Kyker and Swanson (2007), conductivity was positively correlated with agriculture following the application of fertiliser and pesticides. In this present study, the highest readings were in December 2004 and 2005 (57-58 μS/cm), which was the wet season. Lim and Furtado (1982) and Shuhaimi-Othman *et al.* (2007) reported that the highest reading for conductivity was during monsoon or flood season of Tasek Bera and Tasek Chini, respectively.

The general trend exhibited in this study was that conductivity tended to decrease from surface to bottom except at depth of 4 to 5 (Fig. 2.5). Increased conductivity could result from low precipitation, and higher atmospheric temperatures resulting in higher evapo-transpiration rates and higher total ionic concentration. However, it could also be due to a high rate of decomposition and mineralisation by microbes and nutrient regeneration from bottom sediments (Ebenezer and Alex, 2008). The variation in conductivity with depth for Lake Valencia is small and may be explained by an increase in total dissolved salts due to evaporation or other water loss (Mogollon, 1996).

2.3.6 Dissolved Oxygen (DO)

Dissolved oxygen (DO) levels in natural waters and wastewaters depend on the physical (temperature and pressure), chemical (concentrations of various ions) and biochemical activities in the water body (Hutchinson, 1957 and APHA, 1992). The analysis for DO is a key test in water pollution and waste treatment process control.

Oxygen gas dissolves freely in freshwater. It may be added to the water from the atmosphere or as a by-product of photosynthesis from aquatic plants, and is utilised by many respiratory biochemicals, as well as by inorganic chemical reactions (Wetzel and Likens, 2000). The solubility of oxygen is water affected non-linearly by temperature (increases considerably in cold water) and pressure (Wetzel, 2001).

Dissolved oxygen concentration of the 11 sampling sites in Tasek Bera varied from 2.02 mg/L to 5.25 mg/L (Table 2.4). This was not much different than Tasek Chini as recorded by Gasim *et al.* (2006b), Shuhaimi-Othman and Lim, (2006) and Shuhaimi-Othman *et al.* (2007). However a recent report by Shuhaimi-Othman *et al.* (2009) for Tasek Chini was lower. Ikusima *et al*. (1982) recorded that DO for Tasek Bera ranged from 0.80 to 9.02 mg/L, and discovered that the littoral area produced highest concentration compared to sublittoral and limnetic areas. Sim (2002) recorded DO for Tasek Bera ranging from 0.23 mg/L to 5.05 mg/L, which was similar to present study (Table 2.3). Sim *et al.* (2008) reported that DO for Putrajaya Lake ranged from 0.78 mg/L to 13.25 mg/L. Yule and Gomez, (2009) recoded DO for North Selangor Peat Swamp Forest ranged from 1.8 to 16 mg/L. They concluded that the low oxygen levels occurred due to the lack of flow, the accumulation of decaying organic matter that depletes oxygen, and the lack of photosynthesis. These could be the same reasons why the DO reading in Tasek Bera was very low. The mean DO values among the sites were significantly different ($p< 0.05$). Lubuk Ranting Patah, which was surrounded by secondary forest, showed the lowest reading followed by Lubuk Benal. Tanjung Bahau, one of the open water areas, showed the highest reading of DO.

The mean DO among depths were significantly different ($p<0.05$). From the surface down to 2 m the readings were higher compared to the deeper strata except for 6 to 7 m (Fig. 2.5). Zakaria-Ismail and Sabariah (1995) and Rangel *et al.* (2009) reported the DO values for Temenggor Lake and Lake Monte Alegre, Southeast Brazil, respectively, decreased rapidly towards the bottom. In shallow lakes like Tasek Bera with some areas grown with submerged hydrophytes, decomposition of the macrophytes and attached microflora at the end of growing season can reduce the DO. The littoral aquatic plants such as *Lepironia* sp., *Pandanus* sp. and algae that inhabit large areas of Tasek Bera generated large amounts of oxygen by photosynthesis (Ikusima *et al*., 1982). However, the readings between the 3 sampling times didn't show significant differences (3.6 mg/L to 3.7 mg/l); only the early morning (0600 hours) readings were slightly higher (Fig. 2.6). At night large quantities of oxygen are utilised in respiration and decomposition by littoral bacteria in a zone rich in dissolved and particulate organic matter (Wetzel, 2001). Ikusima *et al.* (1982) recorded the DO increased gradually after dawn and reached its maximum around 15:00 hours, and then gradually decreased. Mungoma (1988) and Chapman and Kramer (1991) discovered that the lowest reading of DO was in the morning and the highest in the afternoon for the Lake Kyoga and the tropical dry forest stream in northwest Costa Rica, respectively. Johnson (1967a) has stated that under normal conditions the oxygen content of pond and semi-stagnant waters may decrease to very low levels during the night, especially after an overcast day. Shuhaimi-Othman *et al.* (2007) concluded that the main factor contributing for DO in Tasek Chini are photosynthesis activities, seasonally variable decomposition rate of organic matter, which are very much correlated with temperature and pH of the water. Chapman and Kramer, (1991) reported that dissolved oxygen was usually low in dry season, but increased during the rainy season. Rangel *et al.* (2009) reported that DO for Lake Monte Alegre in the cool-dry period was less than during the warm-rainy season. However in this present study, the maximum reading of DO was in April 2005 which was the dry season and minimum was in December 2005, was a rainy season. The same case was discovered by Okogwu *et al.* (2009) at Cross River Nigeria and Ekelemu and Zelibe (2006) for Lake Ona (Nigeria). This situation happened possibly because the inflows from runoff bring in decomposing organic matter whose breakdown requires more oxygen.

2.3.7 pH

The concentration of hydrogen ions is expressed as pH (Nebel and Wright, 1996). It is the negative logarithm of the hydrogen ion (H^+) concentration. Acidic water contains extra hydrogen ions (H^+) and basic water contains extra hydroxyl (OH^-) ions.

The average pH readings from 11 sites ranged from 5.0 to 6.6 (Table 2.4), which was lower than reported by Ikusima *et al.* (1982) and slightly different than Putrajaya Wetlands and Tasek Chini as recorded by Sim *et al.* (2008) and Shuhaimi-Othman *et al.* (2007). The pH of North Selangor Peat Swamp Forest recorded by Yule and Gomez (2009) was very low, ranging from 2.6 to 3.8 and pH of Pekan Forest Reserve peat swamp as reported by Shuhaimi-Othman *et al.* (2009) was close to Tasek Bera present range between pH 4.06 to 5.13. Khairul Adha *et al.* (2009) reported that for Batang Kerang, Sarawak, a brown-black water river, a pH of about 4.55 to 5.45. Means varied significantly among sites in this present study ($p<0.05$). Hutchinson (1957) mentioned that the extreme low pH for blackwaters areas is most probably caused by the high concentration of sulphuric acid in bog waters. Shuhaimi-Othman *et al.* (2009) found that pH has significant correlation with metal concentration in the water and sediment. Lubuk Benal (a sublittoral area) had the lowest pH reading while Tanjung Penarikan (a limnetic area) had the highest pH of all sampling sites.

Profiles of pH were significantly different among depths. The lowest mean is at the surface and the highest at 5 m from the surface (Fig. 2.5). Ikusima *et al.* in 1982 stated that there was no significant variation of pH with depth for Tasek Bera (mean 5.33), while Sim (2002) reported pH range from 4.03 to 6.87 (Table 2.3). However, Hussainy (1967), Dunn (1967) and Zakaria-Ismail and Sabariah (1995) reported that the pH of the Vihar Lake, Tropical Fish Culture Research Institute (Malacca) and Temenggor Lake (Perak), respectively, were lower at the bottom than at the surface. The higher pH value could be due to the photosynthetic activity at those depths exceeding the respiratory activity of the organisms. The photosynthetic activity is responsible for the formation of hydroxide alkalinity which may have raised the pH for the fishponds in the Tropical Fish Culture Research Institute, Malacca (Dunn, 1967).

The lowest average pH was recorded at 1400 (Fig. 2.6) while pH at 0600 and 2200 hours were slightly different and not significant. Ikusima *et al.* (1982) reported that the pH of Tasek Bera was consistently higher at about pH 6 in the littoral area between 13:00 and 15:00 hours. Hussainy (1967) showed decreasing pH from 12:00 hours, similar to what Dunn (1967) reported for Malacca fishponds. Hussainy (1967) concluded that the light intensity could inhibit the photosynthesis and cause the pH to drop.

The minimum pH was 4.14 at Lubuk Kuin, taken at the surface in November 2005 and the maximum was 8.60 at Teluk Gedubang at 1 m taken from the surface in May 2005. The pH values increased during the wet seasons, and decreased during in dry seasons. Wu *et al.* (2001) recorded waters in the inlets as well as in the Yuanyang Lake (Taiwan) were more acidic in the dry season and that the acidity had a close correlation with total organic N.

The value of pH in Tasek Bera showed slightly acidic character indicating the water to be in Class III according to Interim National Water Quality Standards (DOE, 1994). Research by Wu *et al.* (2001) determined that acidity of Yuangyang Lake may largely be the result of natural acid leaching from the vegetation, rather than acidic precipitation. Lakes with slightly and higher acidity like Tasek Bera are common in regions of lowlands and bogs (Reid and Wood, 1976).

2.3.8 Hydrogen Sulphide

In APHA (1992), it is stated that hydrogen sulphide (H_2S) naturally comes from the decomposition of organic matter, sometimes from industrial wastes, but mostly from the bacterial reduction of sulphate. The escape of H_2S into the air is responsible for its unpleasant odour and it is very toxic to humans as well as other living organisms. This compound is highly toxic to aerobic organisms because it can bind with cytochrome *c* oxidase which is an enzyme in electron transport systems (Affonso *et al.,* 2004).

The mean concentration of hydrogen sulphide at the 11 sampling sites was very low (less than 7.5 µg/L) at 2 sites it was undetectable (Table 2.4) and the difference was not significantly different compared to Temenggor Lake (Zakaria-Ismail and Sabariah, 1995), where the concentration reach 1020.0 µg/L at the bottom. Research done by Gaudet (1979) at Lake Naivasha, (in Kenya) showed that the concentration of H_2S is very low, with minimum values at the surface and maximum values on the bottom. Lubuk Benal and Lubuk Kuin (opposite Perhilitan's jetty) are sublittoral areas surrounded by *Pandanus* stand and *Lepironia* reed had the highest concentrations of H_2S in this present study. Concentrations of organic volatile sulphur compounds have been found to be much higher in shallow lakes or wetland and littoral habitats (Richards *et al.,* 1991).

The concentration of hydrogen sulphide varied with depth with traces in the surface layers and low concentrations in the middle layers. At 5 m from the surface the concentration was highest (Fig. 2.7). The means were not significantly different among depths. Zakaria-Ismail and Sabariah (1995) reported that the concentration of H_2S increased in deeper waters and attributed this to anaerobic decomposition of submerged plants at the bottom. The same situation was observed in Tasek Bera. Crowe *et al.* (2008) reported that the trace concentrations of sulphide in the metalimnion and hypolimnion could originate from the degradation of S-bearing organic matter, or emanate from bottom sediment.

During the night, the mean concentration of hydrogen sulphide was higher than day time (Fig. 2.8). The concentrations were not significantly different among the 3 sampling occasions. Hansen *et al.* (1978) believed that the release of H_2S mainly happened at night since photosynthetic microorganisms efficiently oxidise the sulphide during the day. Studies by Murray and Heggie (2002) indicate that the levels of H_2S could build to high levels in the bottom waters during periods of stratification with bottom water showing anoxic conditions. Hydrogen sulphide could also escape to the atmosphere during the night when DO is low.

During high water season, which occured in November 2004 and December 2004, the highest value of H_2S (10.00µg/L) was recorded. In the wet season, the decomposition of terrestrial vegetation as well as the great quantities of aquatic and semi-aquatic plant communities that covered a large area of Tasek Bera could be the main causes of the increase of H_2S concentration. Sachidanandamurthy and Yajurvedi (2006) reported that the concentration of H_2S throughout the two years study in Bilikere lake, India was due to the entry of agricultural runoff and occasional flow of sewage into the lake.

2.3.9 Nitrite (NO_2^-)

Wetzel (1983) defines nitrification as the biological conversion of organic and inorganic nitrogenous compounds from a reduced state to a more oxidised state. The process of nitrification (1) oxidises ammonium (from the sediment) to nitrite (NO_2-), and then (2) nitrite is oxidised to nitrate (NO_3-). Nitrites are found in natural waters as an intermediate product in the nitrogen cycle. Nitrite is harmful to fish and other forms of aquatic life.

The average concentration of 11 sites at Tasek Bera ranged between 1.29 µg/L and 20.00 µg/L (Table 2.4). The highest reading was observed at Lubuk Benal while at Lubuk Sanglar the concentration was very low. Lim and Furtado (1982) reported values ranging from 0.00 µg/L to 59.00 µg/L, the maximum is higher than present values (Table 2.3). At Temenggor Lake the mean concentration of NO_2^- at a depth of 30 m ranged from 20.00 µg/L to 310.00 µg/L (Zakaria-Ismail and Sabariah, 1995). Yule and Gomez (2009) recorded the value of NO_2^- of less than 100.00 µg/L in the North Selangor Peat Swamp Forest.

At 3 to 4 m, the mean concentration was highest (15.26 µg/L) and there was no significant difference among depths (Fig. 2.7). Zakaria-Ismail and Sabariah (1995) recorded an increase of NO_2^- concentration in deeper waters. This indicates that the rate of anaerobic decomposition of submerged plants would be higher in waters at the bottom as compared to the surface. The mean concentration of NO_2^- calculated based on values recorded from all sampled depth during each sampling times was highest (8.95 µg/L) at 1400 hours (Fig. 2.8); however the concentration did not show significant difference over the different sampling times.

Nitrite concentrations increase in deforested watersheds because of nitrogen deposition and fertilisation, as well as due to a lack of vegetation that would use the nitrogen compounds for growth and production. Consequently, more nitrogen is leached from the surrounding soil and deposited in the lake. The area surrounding Tasek Bera has been deforested for about 30 years for agriculture. This could contribute to the existence of nitrite in the lake. A range of organic carbon compounds, commonly found in agricultural and domestic pollutants, provide the energy sources in the NO_3^- reduction.

High concentrations of NO_2^- can occur in large rivers in summer under warm, slow-flowing conditions as a result of dissimulator nitrate reduction in anaerobic sediments. Additionally agricultural pollutants are important carbon and nitrogen sources, providing ideal substrates for the aquatic bacteria involved in cycling of nitrogen (Kelso *et al.,* 1997). That could be the reason why the highest reading of NO_2^- (100.0 µg/L) was determined in August 2004 at the time of 1400 hours. Lim and Furtado (1982) suggested that the high reading of this nutrient during the northeast monsoon was cause by the influx from the watershed. Gaudet (1979) reported an increasing of NO_2^- in Lake Naivasha during the rainy season, while Hambright *et al.* (1998) mentioned that nitrification was higher during the flooding season because huge amounts of nitrates and ammonia were washed into Hula Valley peat lands (Israel).

2.3.10 Ammonium (NH_4^+) and Un-ionised Ammonia (NH_3)

In water, ammonia occurs in two forms, which together are called the Total Ammonia Nitrogen, or TAN. Chemically, these two forms are represented as NH_4^+ (ammonium) and NH_3 (ammonia). NH_4^+ is called ionised ammonia because it has a positive electrical charge, and NH_3 is called un-ionised ammonia since it has no charge. This is important, since NH_3, is the form which is toxic to fish and can be estimated from the proportions of NH_4^+ dependent on the dissociation dynamic, which are governed by pH and temperature (Trussell, 1972 and Emerson *et al.,*1975).

The ammonium levels were low, ranging from 7.50 µg/L to 123.40 µg/L (Table 2.4). Teluk Gedubang and Teluk Keminyan showed the highest reading of more than 100.00 µg/L. The un-ionised NH_3 was estimated from the concentration of ammonium ions (Emerson *et al.*, 1975). The ammonia concentrations were much lower than ammonium, ranging from 0.005 µg/L to 0.911 µg/L. Lim and Furtado (1982) reported ammonium ranged from 0.00 µg/L to 767.00 µg/L, which was higher than that obtained in this present study (Table 2.3). Several factors need to be considered for the ammonium values obtained, such as the locality of the sampling site and the different methods that were used in both studies. Sim *et al.* (2008) reported concentration of ammonia ranged from 130.00 µg/L up to 1670.00 µg/L for Putrajaya wetland. Shuhaimi-Othman *et al.* (2007) recorded concentrations of ammonia in Chini Lake ranged from 0.00 µg/L to 597.00 µg/L with the highest reading in wet season when the lake was flooded. Pinnila-A, *et al.* (2007) recorded value of ammonia which ranged from 40.00 µg/L to 1700.00 µg/L for Guatavita Lake, a tropical mountain lake in Colombia.

Both ammonium and ammonia showed the lowest reading at depths of 4 to 5 m from the surface (Appendix 3). For ammonium, the highest reading was at level 2 to 3 m but for ammonia it was at 6 to 7 m (Fig. 2.8). The means were not significantly different among depths for ammonium, and but were different for ammonia ($p<0.05$). Concentrations of ammonium, as recorded by Zakaria-Ismail and Sabariah (1995), increased in deeper waters of Temengor Lake. Robarts and Ward (1978) reported that the ammonium vertical transportation took place from anaerobic hypolimnion to the metalimnion (upward), and factors such as winds, surface of the lake, air temperature and water temperature were take into consideration for the rate of the movement.

There were no significant differences among the 3 sampling times for ammonium and ammonia (Appendix 4). Both ammonium and ammonia showed slightly different readings between 0600 and 1400 hours (Fig. 2.8). Anoxic conditions at bottom strata and especially at night, affect many other chemical processes within the lake that can be detrimental to organisms, such as the conversion of organic nitrate to toxic ammonia (Ramachandran, 2008). The highest concentration of ammonium (350.00 µg/L) and ammonia (1.12 µg/L) were determined in March 2005 during a dry period, probably because the increasing oxidation processes of nitrogen from the nitrate to ammonium state. Lim and Furtado (1982) also reported the same and suggested that reduction happened more in the dry season when the situation enhance the oxidation of nitrogen to ammonium state, and enrichment from the watershed during the southwest monsoon. Gaudet (1979) reported the increase of ammonia was during a stagnant period. However, Shuhaimi-Othman *et al.* (2007) determined the increase of ammonia during the rainy season and also reported the positive correlation with TSS but negative correlation with DO and temperature.

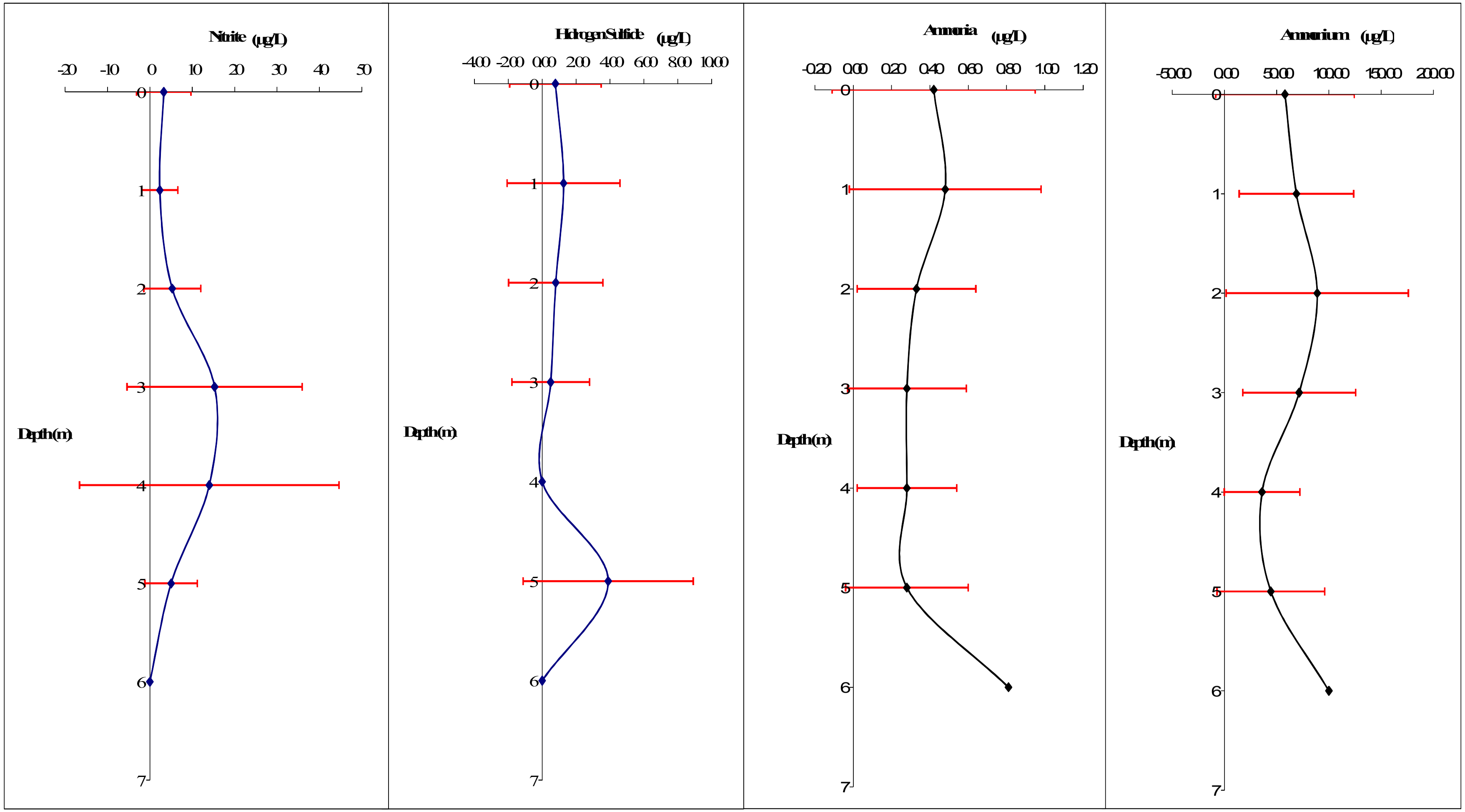


Figure 2.7 Depth profile of nitrite (mg/L), hidrogen sulphide (mg/L), ammonium (µg/L) and ammonia (µg/L) from 11 sampling sites of Tasek Bera. Error bar indicate standard deviation.

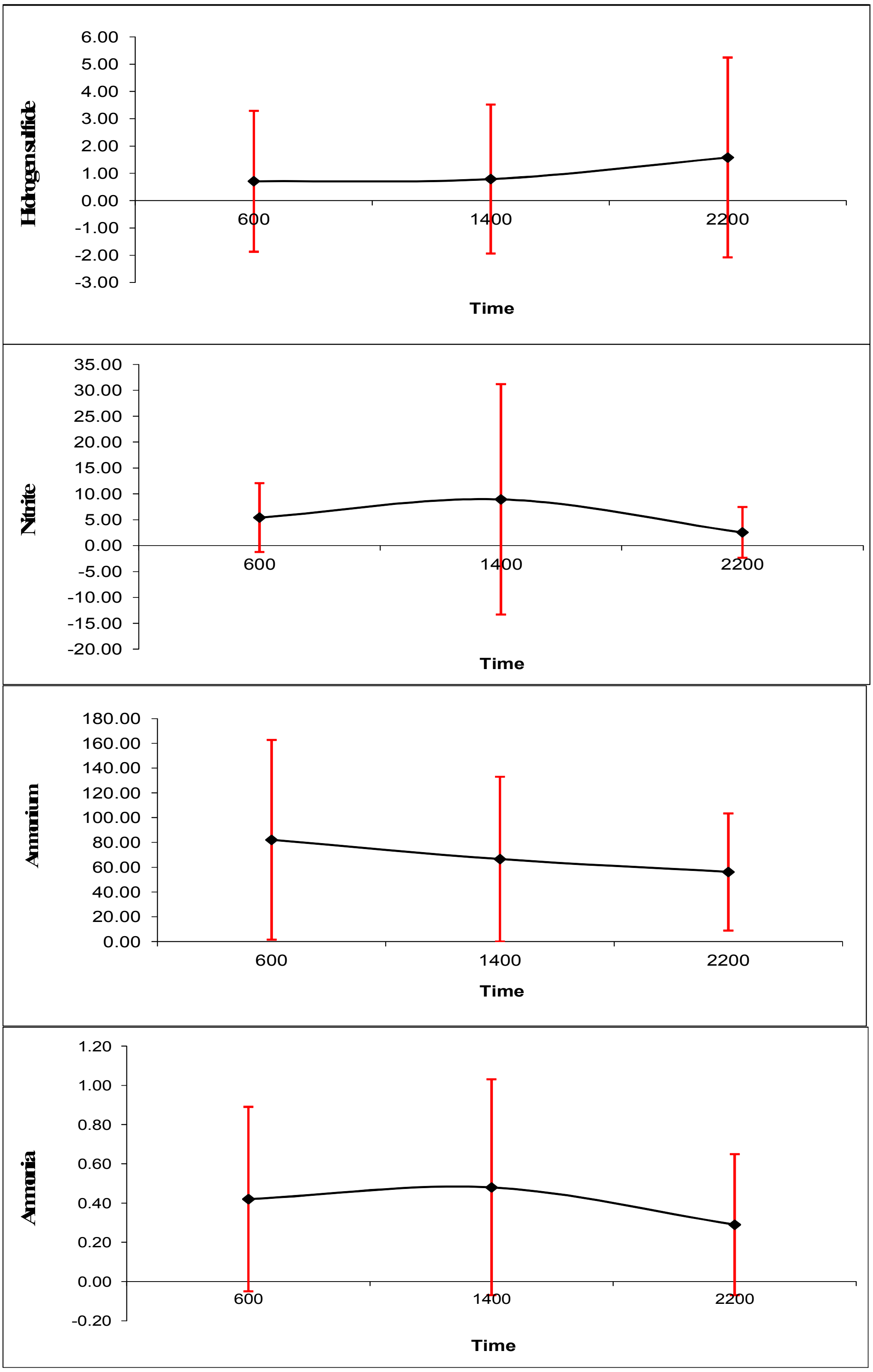


Figure 2.8 Mean of hidrogen sulphide (mg/L), nitrite (mg/L), ammonium (mg/L) and ammonia (mg/L) at 0600, 1400 and 2200 hours. Error bar indicate standard deviation.

CHAPTER 3

THE FISH FAUNA OF TASEK BERA

3.1 INTRODUCTION

The earliest recorded study on fish fauna in the Tasek Bera was by Birtwistle (1932), who reported the occurrence of *Scleropages formosus*, a bonytongue of the family Osteoglossidae. Herre and Myers (1937) recorded *Ambassis ranga,* presently identified as *Parambassis siamensis*, from the area while Hora (1941) examined a young specimen of *Botia hymenophysa.* More species were recorded by Tweedie (1952a, 1952b and 1953), Brittan (1954), Menon (1954) and Alfred (1964). They recorded *Betta pugnax, Cyclocheilicthys heteronema, Kryptopterus limpok, Labiobarbus festivus, Leocassis micropogon, Monotrete palembangensis, Parachela oxygastroides, Puntius johorensis, P. partipentazona, Rasbora cephalotaenia, R. dorsiocellata, R. elegans, R. gracilis* and *R. pauciperforata.*

An icthyofaunal survey by Shiraishi *et al.* (1972) recorded a total of 70 species. Another survey by Mizuno and Furtado (1982) enlarged the species count to about 90. Khan *et al.* (1996) listed only 38 species. A field guide book of Tasek Bera by Sim (2002) was based on compilation of all the earlier studies and indicated the presence of 94 species in the area.

Thus, the objective of this study is to look at the current status of the fish fauna of Tasek Bera wetland. A current species list is compiled based on specimens collected during the current survey as well as specimens deposited in the Museum of Zoology in the Science Faculty, University of Malaya (UMKL) and Zoological Reference Collection (ZRC), National University of Singapore to form the basis of the existing and confirmed presence of fish species in Tasek Bera.

3.2 MATERIALS AND METHODS

The purpose of the study is to unearth as many species recorded from Tasek Bera as possible in order to compare historical records to the current status of the fish diversity in the lake. Sampling was conducted monthly between April 2004 to December 2005 concurrently with the water quality and vertical sampling efforts. Further sampling efforts were conducted opportunistically up to 2007. During the current survey, fishes were caught using an electro-shocker, gill net, cast net, dip net, fish trap and fishing line throughout the entire breadth and length of Tasek Bera wetlands with the exception of Paya Dampar due to logistical reasons as the area was no longer accessible due to undergrowth. Some localities were sampled once while others were sampled several times depending on the logistics and accessibility. Preserved specimens collected from the area and deposited at the Museum of Zoology, University of Malaya were also examined and included in the species list. Only representative samples of each species were kept as specimens and fixed in 10% formalin in the field. In the laboratory, the specimens were soaked in water for several days. They were then transferred into 70% alcohol for long term storage. The preserved specimens were deposited in the Museum of Zoology of the Science Faculty, University of Malaya with an acronym of UMKL. Specimens deposited in the Zoological Reference Collection (ZRC), National University of Singapore were also inspected and included in the study.

The Families are arranged following Nelson (2006). The abbreviation “Sg.” is used for “Sungai”, a Malay word for river, while “Kg.” stands for “Kampung” referring to village. “SL” stands for standard length, and “ex.” is an abbreviation for example. Some of the fish photos are courtesy of Dr. Amiruddin Ahmad from Department of Biology, University Malaysia Terengganu, Dr. Lum Wei Wah and Mr. Vincent Chow of Malaysian Nature Society Johor Branch and En. Mustafa of the Freshwater Fish Research Station, Glemi Lemi, Department of Fisheries. The valid names of certain families and species have been changed recently. The new names of those families and species are listed in Appendix 5.

3.3 SYSTEMATICS ACCOUNT

Family: Osteoglossidae

***Scleropages formosus* (Müller & Schlegel, 1844)**

Plate 1a

Material examined.- UMKL 2856 (1 ex.), UMKL 5629 (2 ex.), UMKL 5869 (1 ex.), UMKL 6004 (1 ex.), ZRC 719 (17 ex.), ZRC 721 (1 ex.), ZRC 723 (10 ex.), ZRC 7923 - 7924 (1 ex.), ZRC 7955 - 7956 (2 ex.), ZRC 8824 (1 ex.), ZRC 8825 - 8826 (2 ex.), ZRC 9171 (1 ex.), ZRC 9172 (1 ex.), ZRC 9173 (1 ex.), ZRC 9174 - 9176 (3 ex.).

Remarks.- The species is locally known as *kelisa.* It was reported to be relatively common in the early 70s (Mizuno & Furtado, 1982) but now it is very rare and has been listed as an endangered species by Anon (1986). It is also protected under Fisheries Enactment 1991 (Pahang State) of the Fisheries Act 1985. It is a valuable aquarium fish and the fries are still caught by locals at night especially between September until December.

Family: Notopteridae

Chitala lopis (Bleeker, 1851)

Plate 1b

Material examined.- UMKL 5866 (1 ex.), ZRC 7976 (1 ex.), ZRC 8814 (1 ex.), ZRC 8820 (1 ex.).

Remarks.- This species is often seen splashing and gulping air at the surface of the open water of the lake especially at dusk. It is the rarer of the two *belida* or featherback found in the area. It was reported as *Notopterus chitala* by Mizuno and Furtado (1982).

Notopterus notopterus (Pallas, 1769)

Plate 1c

Material examined.- UMKL 807 (1 ex.), UMKL 2556 (2 ex.), UMKL 2560 (1 ex.), UMKL 5857 (1 ex.), ZRC 2826 (4 ex.), ZRC 2829 (1 ex.), ZRC 3128 (5 ex.), ZRC 5645 - 5648 (4 ex.), ZRC 7972 (1 ex.), ZRC 8046 (1 ex.), ZRC 8168 (1 ex.), ZRC 8169 - 8173 (5 ex.), ZRC 8817 - 8818 (2 ex.), ZRC 8821 - 8822 (2 ex.).

Remarks.- This is the more common featherback in the wetland. It can be found inhabiting still and sluggish water areas of the lake. The species is not a popular food fish because of the presence of intra-muscular bones, but sometimes it is reared as an ornamental fish.

Family: Cyprinidae

Amblyrhynchichthys truncatus (Bleeker, 1851)

Plate 1d

Material examined.- UMKL 2912 (1 ex.).

Remarks.- This is the only specimen in the Museum of Zoology of the Science Faculty, University of Malaya collection indicating the presence of the species in Tasek Bera swamp. The specimen was collected in 1992 and it is considered to be locally extinct.

Balantiocheilos melanopterus (Bleeker, 1851)

Plate 1e

Material examined.- UMKL 48 (1 ex.).

Remarks.- This specimen was collected in 1969. The species is considered to have become extinct (Zakaria-Ismail, 1991a) not only in Tasek Bera but also throughout much of Peninsular Malaysia.

Barbichthys laevis (Valenciennes *in* Cuvier & Valenciennes, 1842)

Plate 1f

Material examined.- UMKL 2907 (1 ex.).

Remarks.- The species is found in all major rivers of Peninsular Malaysia. A specimen collected by Khan *et al.* (1996) is the only record of the species in the area.

Barbonymus schwanenfeldii (Bleeker, 1853)

Plate 1g

Material examined.- UMKL 788 (10 ex.), UMKL 5783 (2 ex.), UMKL 5789 (1 ex.), UMKL 5823 (1 ex.), UMKL 5873 (1 ex.), UMKL 5878 (1 ex.).

Remarks.- Previously, it was widely reported under the genera *Puntius* or *Barbodes*. Locally known as *lampam sungai*, the species seems to occupy deeper sections of the lake particularly near Lubuk Kuin, Chederong and Benal.

Boraras maculatus (Duncker, 1904)

Plate 1h

Material examined.- UMKL 5900 (1 ex.), UMKL 6000 (29 ex.).

Remarks.- This is the first record of the species in Tasek Bera. It is a very small cyprinid which prefers large marshes and swampy areas with dense growth of semi aquatic plants near Paya Tembangau and Kg. Pathir's Jetty particularly during rainy season.

Chela laubuca (Hamilton, 1822)

Plate 2a

Material examined.- UMKL 6019 (1 ex.), ZRC 3181 (5 ex.).

Remarks.- This is the first time the species is being recorded in Tasek Bera . One specimen was caught in a swampy area near Paya Jelawat. Another five old specimens (ZRC 3181) collected previously at Tasek Bera labelled as *C. maassi* refers to this species.

Cyclocheilichthys apogon (Valenciennes _in_ Cuvier & Valenciennes, 1842)

Plate 2b

Material examined.- UMKL 2776 (1 ex.), UMKL 2895 (30 ex.), UMKL 2919 (1 ex.), UMKL 4299 (10 ex.), UMKL 4363 (2 ex.), UMKL 5777 (2 ex.), UMKL 5787 (1 ex.), UMKL 5825 (11 ex.), UMKL 5828 (1 ex.), UMKL 5861 (2 ex.), UMKL 5874 (1 ex.), UMKL 6030 (4 ex.), ZRC 1802 (2 ex.), ZRC 1805 (36 ex.), ZRC 8103 - 8126 (24 ex.), ZRC 8127 - 8142 (16 ex.), ZRC 19584 - 19592 (9 ex.).

Remarks.- One of the most abundant species that was caught in all types of habitat at the study area. They are normally caught in large number using cast net and also gill net.

Cyclocheilichthys heteronema (Bleeker, 1853)

Plate 2c

Material examined.- UMKL 2618 (5 ex.), UMKL 2916 (2 ex.), UMKL 4279 (2 ex.), UMKL 5794 (2 ex.), UMKL 5802 (1 ex.), UMKL 5807 (1 ex.).

Remarks.- A rather common *Cyclocheilichthys* in Tasek Bera. Recent collections suggest that shallow parts of the lake which otherwise dried up during drought season is its preferred habitat.

Cyclocheilichthys repasson (Bleeker, 1853)

Plate 2d

Material examined.- UMKL 2557 (3 ex.), UMKL 2920 (3 ex.), ZRC 1817 (2 ex.).

Remarks.- All six specimens were caught in 1992. The species is the most common *Cyclocheilichthys* in large rivers of Peninsular Malaysia (Zakaria-Ismail, 1993), and probably migrates into the lake for spawning during the flooding season.

Epalzeorhynchos kalopterus (Bleeker, 1851)

Plate 2e

Material examined.- ZRC 1827 (1 ex.).

Remarks.- A specimen caught in 1940 and deposited at ZRC is the only record of the species from the area. The species is considered to have become locally extinct.

Hampala macrolepidota Kuhl & Van Hasselt, 1823

Plate 2f

Material examined.- UMKL 57 (1 ex.), UMKL 2629 (2 ex.), UMKL 4300 (1 ex.), UMKL 5786 (1 ex.), UMKL 5824 (2 ex.), UMKL 5836 (1 ex.), UMKL 6034 (4 ex.), ZRC 1847 (2 ex.), ZRC 7960 (1 ex.), ZRC 7961 (1 ex.), ZRC 7962 (1 ex.), ZRC 7982 - 7987 (6 ex.), ZRC 7988 (1 ex.), ZRC 8823 (1 ex.), ZRC 8846 - 8847 (2 ex.), ZRC 12159 (1 ex.).

Remarks.- Locally known as *sebarau,* it is the most common predatory cyprinid fish in the lake. In riverine habitat, the species prefers streams with sandy and muddy substrates. In the lake, most of the specimens were caught in the open water areas surrounded with *Pandanus* plant.

Labiobarbus festivus (Heckel, 1843)

Plate 2g

Material examined.- UMKL 2627 (3 ex.), UMKL 2976 (1 ex.), UMKL 4293 (11 ex.), UMKL 5774 (3 ex.), UMKL 5792 (1 ex.), UMKL 5801 (1 ex.), UMKL 5806 (1 ex.), UMKL 5811 (1 ex.), ZRC 7977 (1 ex.), ZRC 8045 (1 ex.), ZRC 8063 - 8068 (6 ex.), ZRC 12014 – 12151 (138 ex.).

Remarks.- This is the most common Cyprinidae and it can be found throughout the entire range of Tasek Bera. Because of their schooling behavior, members of the species can be caught in large numbers using a gill net.

Labiobarbus leptocheilus (Valenciennes *in* Cuvier & Valenciennes, 1842)

Plate 2h

Material examined.- UMKL 2628 (2 ex.), UMKL 2774 (1 ex.), UMKL 2779 (1 ex.), UMKL 2917 (1 ex.), UMKL 4360 (1 ex.).

Remarks.- All specimens examined were caught in 1992. It is probably a migratory species that uses Tasek Bera temporarily.

Labiobarbus ocellatus (Heckel, 1843)

Plate 3a

Material examined.- UMKL 2915 (1 ex.).

Remarks.- Record of the species in the area is based on only one specimen caught in 1992. It is usually found in large rivers throughout much of Peninsular Malaysia.

Leptobarbus hoevenii (Bleeker, 1851)

Plate 3b

Material examined.- UMKL 79 (1 ex.), UMKL 5879 (1 ex.), ZRC 2303 (10 ex.), ZRC 5641- 5644 (4 ex.), ZRC 7925 (1 ex.), ZRC 7957 (1 ex.).

Remarks.- It is not a common species. Recent specimens were caught during the wet season at an inundated area near Kg. Pathir.

Luciosoma setigerum (Valenciennes *in* Cuvier & Valenciennes, 1842)

Plate 3c

Material examined.- UMKL 3465 (1 ex.), ZRC 1322 (1 ex.).

Remarks.- Although it is the most common *Luciosoma* in large rivers flowing through lowland areas such as Sg. Pahang and Sg. Endau (Zakaria-Ismail, 1987), the species is rare in the water body.

***Luciosoma trinema* (Bleeker, 1852)**

Plate 3d

Material examined.- UMKL 5779 (1 ex.), UMKL 5790 (1 ex.), UMKL 5798 (1 ex.), UMKL 5804 (1 ex.), UMKL 5805 (1 ex.), UMKL 5809 (1 ex.), ZRC 1324 (5 ex.).

Remarks.- This is apparently the most common *Luciosoma* in lacustrine but not riverine habitats. It was often caught hiding under the jetty, surrounded by small *Pandanus* trees.

***Macrochirichthys macrochirus* (Valenciennes *in* Cuvier & Valenciennes, 1844)**

Plate 3e

Material examined.- ZRC 1314 (2 ex.), ZRC 1315 (4 ex.), ZRC 1317 (4 ex.).

Remarks.- Ten specimens, caught in 1967 and 1969 and deposited at ZRC, are the only record of the species in Tasek Bera . This species is considered to have become locally extinct. It has not been caught from the area for the last 30 years.

***Osteochilus hasseltii* (Valenciennes *in* Cuvier & Valenciennes, 1842)**

Plate 3f

Material examined.- UMKL 2908 (1 ex.), UMKL 4273 (2 ex.), UMKL 5826 (4 ex.), UMKL 5856 (3 ex.), UMKL 5860 (1 ex.), UMKL 5875 (1 ex.), UMKL 5898 (1 ex.), UMKL 6032 (5 ex.), ZRC 636 (27 ex.), ZRC 8102 (1 ex.).

Remarks.- The most abundant and widely distributed *Osteochilus* not only in Tasek Bera but also in Peninsular Malaysia. The species inhabits all kinds of habitats including black water swamps.

***Osteochilus melanopleurus* (Bleeker, 1852)**

Plate 3g

Material examined.- UMKL 5778 (3 ex.), ZRC 2304 (5 ex.), ZRC 7942-7944 (3 ex.), ZRC 7948-7949 (2 ex.), ZRC 7950-7951 (2 ex.), ZRC 8984-8997(14 ex.).

Remarks.- This is the largest *Osteochilus* in Peninsular Malaysia. Recent specimens were caught near Lubuk Salleh which has the depths of about 7-8 m. The species is normally found in large, lowland rivers in Peninsular Malaysia (Zakaria-Ismail, 1987).

Osteochilus microcephalus (Valenciennes _in_ Cuvier & Valenciennes, 1842)

Plate 3h

Material examined.- UMKL 2914 (1 ex.).

Remarks.- A specimen deposited in the Museum of Zoology (UM) was caught in 1992. It is not a very common species but widely distributed throughout much of Peninsular Malaysia (Zakaria-Ismail, 1987).

Osteochilus spilurus (Bleeker, 1851)

Plate 4a

Material examined.- ZRC 19593 (1 ex.), ZRC 8101 (1 ex.), ZRC 8925-8983 (59 ex.).

Remarks.- A relatively common *Osteochilus* in the area although it is not abundant as compared to *O. hasseltii*. Specimens deposited at ZRC are the only record of the species from Tasek Bera.

Osteochilus waandersii (Bleeker, 1852)

Plate 4b

Material examined.- UMKL 5812 (1 ex.), UMKL 5876 (1 ex.).

Remarks.- This species is normally found in a relatively large, fast-flowing river with rocky substrate. Recent specimens were caught near Lubuk Ranting Patah and Lubuk Chenderong of Tasek Bera.

Oxygaster anomalura van Hasselt, 1823

Plate 4c

Material examined.- UMKL 5788 (1 ex.), UMKL 5834 (1 ex.), UMKL 5998 (2 ex.), UMKL 6036 (2 ex.).

Remarks.- It usually inhabits relatively large, deep streams as well as rivers flowing through lowland areas. This species was caught particularly at the shallow parts of the lake.

Parachela hypopthalmus (Bleeker, 1860)

Plate 4d

Material examined.- UMKL 2896 (1 ex.), UMKL 2897 (2 ex.), UMKL 2898 (1 ex.), UMKL 4276 (7 ex.), UMKL 5799 (1 ex.), UMKL 5886 (1 ex.), UMKL 5899 (1 ex.), UMKL 6014 (1 ex.), ZRC 1421 (18 ex.), ZRC 1794 (4 ex.), ZRC 3179 (7 ex.).

Remarks.- This species was caught particularly at the shallow parts of the lake. It is usually found in relatively large rivers flowing through lowland areas and substrates consisting of mud and sand (Zakaria-Ismail, 1987). Specimens ZRC 1794 and ZRC 3179, labelled as *Oxygaster johorensis*, are actually *P. hypopthalmus*.

Parachela oxygastroides (Bleeker, 1852)

Plate 4e

Material examined.- UMKL 2630 (1 ex.), UMKL 4365 (5 ex.), UMKL 5773 (1 ex.), UMKL 5775 (3 ex.), UMKL 5796 (4 ex.), UMKL 5829 (1 ex.), UMKL 5877 (1 ex.), UMKL 5887 (1 ex.), UMKL 5888 (3 ex.), UMKL 5999 (1 ex.), UMKL 6025 (3 ex.), ZRC 1312 (10 ex.), ZRC 1979 (1 ex.), ZRC 3182 (5 ex.), ZRC 11843-11846 (4 ex.).

Remarks.- A widely distributed and abundant cyprinid in Tasek Bera. It was found is all types of habitat in the lake.

Puntioplites bulu (Bleeker, 1851)

Plate 4f

Material examined.- UMKL 5822 (1 ex.), ZRC 715 (8 ex.), ZRC 716 (14 ex.), ZRC 7926-7934 (9 ex.), ZRC 7935 (1 ex.), ZRC 7936 (1 ex.), ZRC 7937 (1 ex.), ZRC 7938-7939 (2 ex.), ZRC 7940-7941 (2 ex.), ZRC 7952 (1 ex.), ZRC 8154-8163 (10 ex.), ZRC 8164 (1 ex.), ZRC 8165-8167 (3 ex.), ZRC 8829 (1 ex.).

Remarks.- This species is normally caught by local fishermen during the dry season, especially in March, by using hook and line baited with small fish. It can grow more than 300 mm in total length. It was reported as *Puntius bulu* by Mizuno and Furtado (1982).

Puntius binotatus (Valenciennes *in* Cuvier & Valenciennes, 1842)

Plate 4g

Material examined.- UMKL 4304 (1 ex.), UMKL 6023 (2 ex.), ZRC 542 (1 ex.), ZRC 8084 (1 ex.).

Remarks.- Adults of this species usually have one small round black spot at the base of dorsal-fin origin, and another black spot at the middle of caudal peduncle. It is among the most successful cyprinids not only in Peninsular Malaysia but also throughout its entire range in Southeast Asia (Zakaria-Ismail, 1994). However, only two specimens were caught near Paya Jelawat recently.

Puntius johorensis (Duncker, 1904)

Plate 4h

Material examined.- UMKL 4303 (6 ex.), UMKL 4362 (12 ex.), UMKL 5833 (2 ex.), UMKL 5880 (3 ex.), UMKL 6031 (3 ex.), ZRC 564 (7 ex.), ZRC 565 (27 ex.), ZRC 2301 (1 ex.).

Remarks.- This species is commonly found in blackwater swamps with high acidity. Much of the specimens were collected using hook and line baited with worm. A relatively abundant species in it's preferred habitat. In the literature, the species has been reported as *Puntius eugrammus* or *P. fasciatus* (Zakaria-Ismail, 1991a).

Puntius lineatus (Duncker, 1904)

Plate 5a

Material examined.- UMKL 4278 (3 ex.).

Remarks.- A very rare species in Peninsular Malaysia (Zakaria-Ismail, 1991b). All three specimens examined were caught in 1982 near Pos Iskandar. It has not been collected since. The species is considered to be extinct in the area

Puntius partipentazona (Fowler, 1934)

Plate 5b

Material examined.- UMKL 2656 (14 ex.), UMKL 3184 (3 ex.), UMKL 5850 (10 ex.), ZRC 501 (97 ex.), ZRC 503 (75 ex.), ZRC 3204 (200 ex.), ZRC 8181-8190 (15 ex.).

Remarks.- It is a beautiful and popular aquarium fish. Usually they are found swimming in large groups. This species was listed as *Puntius tetrazona tetrazona* by Mizuno and Furtado (1982).

Rasbora cephalotaenia (Bleeker, 1852)

Plate 5c

Material examined.- UMKL 5793 (1 ex.), UMKL 5795 (1 ex.), UMKL 5832 (3 ex.), UMKL 6001 (2 ex.), UMKL 6021 (2 ex.), ZRC 1699 (7 ex.), ZRC 3205 (10 ex.).

Remarks.- This species is common in blackwater habitats. Recent specimens were collected in the shallow parts of the lake overgrown with *Lepironia* reed and *Pandanus* plant.

Rasbora dorsiocellata Duncker, 1904

Plate 5d

Material examined.- UMKL 3163 (2 ex.), UMKL 3182 (2 ex.), UMKL 5882 (2 ex.), UMKL 5835 (1 ex.), UMKL 5885 (1 ex.), UMKL 6013 (3 ex.), ZRC 1687 (237 ex.), ZRC 3206 (200 ex.), ZRC 8179-8180 (2 ex.).

Remarks.- A beautiful and common *Rasbora* of the shallow areas surrounded by plants particularly the *Pandanus* and *Lepironia*.

Rasbora dusonensis (Bleeker, 1851)

Plate 5e

Material examined.- UMKL 2508 (1 ex.), UMKL 3174 (1 ex.), UMKL 5797 (1 ex.), UMKL 5831 (7 ex.), UMKL 5881 (3 ex.), UMKL 6026 (14 ex.), ZRC 1717 (10 ex.), ZRC (5 ex.).

Remarks.- A relatively large and one of the most common rasborine fishes in the lake. This species has a dark, broad lateral stripe from operculum to caudal base. Specimens from ZRC were labelled as *Rasbora myersi*.

Rasbora einthovenii (Bleeker, 1851)

Plate 5f

Material examined.- UMKL 4280 (39 ex.), UMKL 5837 (1 ex.), UMKL 5896 (34 ex.), UMKL 6018 (7 ex.), ZRC 1750 (1 ex.).

Remarks.- This species shows a black lateral stripe with uneven margins from the tip of lower jaw to the end of median caudal-fin ray. It can be found normally in blackwater swamps and streams. Individuals of the species were caught in large numbers as they always swim in groups.

Rasbora elegans Volz, 1903

Plate 5g

Material examined.- UMKL 4361 (1 ex.), ZRC 1434 (1 ex.), ZRC 1750 (1 ex.).

Remarks.- The presence of the species in Tasek Bera was reported by Mizuno and Furtado (1982) based on the record of Brittan (1954). Three specimens deposited in the UMKL and ZRC are evidence of the presence of the species in the area.

Rasbora pauciperforata Weber and de Beaufort, 1916

Plate 5h

Material examined.- ZRC 1693 (121 ex.), UMKL 6037

Remarks.- The species prefers mid-water as well as surface waters overgrown with aquatic plants and covered with extensive forest canopies.

Rasbora pauciqualis Ahl _in_ Schreitmüller, 1935

Plate 6a

Material examined.- UMKL 5897 (6 ex.), UMKL 6002 (6 ex.),

Remarks.- One of the most common cyprinid fishes in Tasek Bera. Members of the species occasionally form large swarms swimming on the surface water. It was recorded as *Rasbora bankanensis* by Khan *et al.* (1996).

***Thynnichthys thynnoides* (Bleeker, 1852)**

Plate 6b

Material examined.- UMKL 2910 (1 ex.), UMKL 5772 (1 ex.), UMKL 5821 (1 ex.).

Remarks.- Recent specimens were caught near to the shore of the lake surrounded by *Pandanus* stands.

***Trigonostigma heteromorpha* (Duncker, 1904)**

Palte 6c

Material examined.- UMKL 5895 (23 ex.), UMKL 6016 (1 ex.), ZRC 1713 (49 ex.).

Remarks.- Previously known as *Rasbora heteromorpha*, this species is a small fish attaining not more than 35 mm in total length. It has a black triangular blotch occupying the posterior half on each side of the body. Individuals of the species were caught in large numbers near Paya Tembangau, one of the swamps that meet the main lake.

Family: Cobitidae

***Acanthopsoides molobrion* Siebert, 1991**

Plate 6d

Material examined.- UMKL 5989 (5 ex.).

Remarks.- This is the first record of the species in Tasek Bera. It has a relatively longer head and small body size than other species of Cobitidae. It is usually found in large rivers flowing through lowland areas with sandy and muddy substrates overgrown with aquatic vegetation (Zakaria-Ismail, 1993).

***Botia hymenophysa* (Bleeker, 1852)**

Plate 6e

Material examined.- UMKL 5981 (2 ex.).

Remarks.- The species prefers swampy areas overgrown with aquatic vegetation particularly near Paya Tembangau.

***Lepidochephalichthys furcatus* (de Beaufort, 1933)**

Plate 6f

Materila examined.- UMKL 6008 (2 ex.).

Remarks.- This is the only *Lepidochephalichthys* having forked tail. The specimens represent the first record of the species in Tasek Bera Wetlands. Two individuals were caught in swampy area and stagnant streams with dense vegetation near Paya Jelawat.

***Pangio malayana* (Tweedie, 1956)**

Plate 6g

Material examined.- UMKL 6007 (5 ex.).

Remarks.- This is the first record of the species in Tasek Bera. It is normally found in large, slow-flowing rivers with sand and silt as substrate (Zakaria-Ismail, 1993). Recent specimens were caught near Paya Jelawat.

***Pangio semicincta* (Fraser-Brunner, 1940)**

Plate 6h

Material examined.- UMKL 5991 (1 ex.), UMKL 6010 (1 ex.).

Remarks.- It was recorded as *Pangio kuhlii* by Khan *et al.* (1996). Only two individuals were collected by using a dip net near Paya Tembangau and Paya Jelawat. It is usually hides under the leaf-litter and detritus of the swampy area.

***Pangio shelfordii* (Popta, 1903)**

Plate 7a

Material examined.- UMKL 6142 (1 ex.).

Remarks.- Only one individual was caught at Paya Jelawat, part of Tasek Bera. This is the first record of the species from the lake.

Family: Balitoridae

***Nemacheilus selangoricus* Duncker, 1904**

Plate 7b

Material examined.- UMKL 5906 (1 ex.), UMKL 6009 (1 ex.), ZRC 1469 (2 ex.).

Remarks.- The species usually inhabits small streams flowing through lowland areas with rocky substrate (Zakaria-Ismail, 1993); however, it can be found in swampy areas.

Family: Bagridae

***Hemibagrus bleekeri* (Volz, 1903)**

Plate 7c

Material examined.- UMKL 2558 (1 ex.), UMKL 4274 (1 ex.), UMKL 5854 (1 ex.), UMKL 5867 (1 ex.), UMKL 5872 (1 ex.), ZRC 3053 (1 ex.),ZRC 7966 (1 ex.), ZRC 8053-8054 (2 ex.), ZRC 8055 (1 ex.), ZRC 8057 (1 ex.), ZRC 8058 (1 ex.), ZRC 8819 (1 ex.), ZRC 8830 (1 ex.), ZRC 8831-8834 (4 ex.), ZRC 8843-8845 (3 ex.), ZRC 9556-9561 (6 ex.).

Remarks.- This species was previously known as *Hemibagrus nemurus*. It can be found in all types of habitats in Tasek Bera. It is one of the most important food fishes.

Leoicassis poecilopterus (Valenciennes *in* Cuvier & Valenciennes, 1840)

Plate 7d

Material examined.- UMKL 5894 (3 ex.).

Remarks.- Recent surveys managed to catch three specimens in Paya Tembangau by using a dip net. It is one of the rare species in Tasek Bera. It's preferred habitat is small streams flowing through forested area (Zakaria-Ismail, 1993).

Mystus singaringan (Bleeker, 1846)

Plate 7e

Material examined.- UMKL 2778 (1 ex.), UMKL 2909 (1 ex.), UMKL 2911 (3 ex.), UMKL 4288 (3 ex.), UMKL 5849 (1 ex.), UMKL 5852 (1 ex.), UMKL 5871 (1 ex.), UMKL 5902 (2 ex.), UMKL 6029 (2 ex.).

Remarks.- This species was previously known as *Mystus macronemus* or *Mystus nigriceps*. It is not as common as *Hemibagrus nemurus*. Members of the species are commonly found in rivers flowing through lowland areas with sandy and muddy substrates (Zakaria-Ismail, 1993).

Family: Siluridae

Kryptopterus apogon (Bleeker, 1851)

Plate 7f

Material examined.- UMKL 325 (1 ex.), UMKL 344 (1 ex.), UMKL 510 (1 ex.), UMKL 2625 (1 ex.), UMKL 2691 (1 ex.), UMKL 5776 (2 ex.), UMKL 5780 (2 ex.), UMKL 5803 (1 ex.), UMKL 5863 (1 ex.), UMKL 5864 (1 ex.), UMKL 5890 (4 ex.), ZRC 7912-7913 (2 ex.), ZRC 8061 (1 ex.), ZRC 8069-8070 (2 ex.), ZRC 8816 (1 ex.), ZRC 8827-8828 (2 ex.), ZRC 8835-8836 (2 ex.), ZRC 8839 (1 ex.), ZRC 12152 -12155 (4 ex.).

Remarks.- This species is one of the most common silurid fishes in Tasek Bera. They were caught mostly in open water areas of the lake.

Kryptopterus bicirrhis **(Valenciennes *in* Cuvier & Valenciennes, 1840)**

Plate 7g

Material examined.- UMKL 326 (2 ex.), UMKL 2918 (1 ex.).

Remarks.- This *Kryptopterus* has a transparent body. It can be found not only in swampy areas but also in clear-water sections of the lake. The two specimens examined were caught in the 1973 and 1992, respectively.

Kryptopterus limpok **(Bleeker, 1852)**

Plate 7h

Material examined.- UMKL 5819 (1 ex.), UMKL 5862 (2 ex.), UMKL 5892 (7 ex.), ZRC 2975 (4 ex.).

Remarks.- This species is common in swampy areas of the lake.

Kryptopterus macrocephalus **(Bleeker, 1858)**

Plate 8a

Material examined.- UMKL 2777 (2 ex.), UMKL 2899 (1 ex.), UMKL 5884 (1 ex.), UMKL 5893 (1 ex.), UMKL 6037 (2 ex.), ZRC 2981 (2 ex.), ZRC 3242 (80 ex.), ZRC 19600-19602 (3 ex.).

Remarks.- Another common silurid catfish from the area.

***Kryptopterus moorei* Smith, 1945**

Plate 8b

Material examined.- ZRC 5633-5634 (2 ex.).

Remarks.- The rarest silurid catfish in Tasek Bera. The presence of the species in the area is based on only two specimens deposited in ZRC, Singapore.

***Ompok eugeneiatus* (Vaillant, 1893)**

Plate 8c

Material examined.- UMKL 6038

Remarks.- This species was first recorded in Peninsular Malaysia by Khan (1996) from Pahang River Basin. Its presence in Tasek Bera is based on a specimen collected in 1997.

***Ompok fumidus* Tan & Ng, 1996**

Plate 8d

Material examined.- ZRC 2967 (1 ex.).

Remarks.- Its occurrence in the area is based on a single specimen deposited at ZRC, Singapore.

***Ompok hypopthalmus* (Bleeker, 1846)**

Plate 8e

Material examined.- UMKL 328 (1 ex.), UMKL 2510 (1 ex.), UMKL 5781 (1 ex.), UMKL 5791 (5 ex.), UMKL 5818 (1 ex.), ZRC 7914-7919 (6 ex.), ZRC 8062 (1 ex.), ZRC 8071 (1 ex.), ZRC 12156-12158 (3 ex.).

Remarks.- This species was caught in open-water areas of the lake. It was reported by Khan *et al.* (1996) and Mizuno and Furtado (1982) as *Silurodes hypophthalmus.* Ng (2003) has done a review of this silurid catfish.

Silurichthys hasseltii Bleeker, 1858

Plate 8f

Material examined.- UMKL 6028 (1 ex.).

Remarks.- It is one of the most common *Silurichthys* found in Peninsular Malaysia. However, its presence in the lake is based on only one specimen.

Wallago leerii Bleeker, 1851

Plate 8g

Material examined.- UMKL 2825 (1 ex.),UMKL 5858 (1 ex.), UMKL 5868 (1 ex.), ZRC 6978-6979 (2 ex.), ZRC 6980-6981 (2 ex.), ZRC 7920-7921 (2 ex.), ZRC 7953 (1 ex.), ZRC 7954 (1 ex.), ZRC 8049 (1 ex.), ZRC 8803 (1 ex.), ZRC 8812-8813 (2 ex.), ZRC 8841-8842 (2 ex.).

Remarks.- This species is the largest of all silurid fishes. It has extremely long anal-fin base. The species was reported as *Wallagonia miostoma* by Furtado and Mori (1982).

Family: Akysidae

Akysis alfredi Ng & Kottelat, 1998

Plate 8h

Material examined.- ZRC 40714 (1 ex. Holotype), ZRC 20755-20757 (3 ex. Paratypes).

Remarks.- This species was recently described by Ng and Kottelat (1998). Tasek Bera is its type locality.

Family: Clariidae

Clarias batrachus (Linnaeus, 1758)

Plate 9a

Material examined.- ZRC 2589 (1 ex.).

Remarks.- Although the species is common in swampy areas and also in paddy fields throughout Peninsular Malaysia (Zakaria-Ismail, 1987), the occurrence of the species in the lake is based on only one specimen deposited at ZRC, Singapore.

Clarias meladerma Bleeker, 1846

Plate 9b

Material examined.- UMKL 2616 (1 ex.), UMKL 6005 (1 ex.).

Remarks.- The presence of serration on the front margin of pectoral-fin spines distinguishes the species from all other clariid catfishes in Malaysia. It is a rather rare species not only in Tasek Bera but also throughout much of Peninsular Malaysia (Zakaria-Ismail, 1997). It was found in areas with muddy substrates and covered with heavy canopy.

Clarias nieuhofii Valenciennes *in* Cuvier & Valenciennes, 1840

Plate 9c

Material examined.- UMKL 2615 (1 ex.), UMKL 2617 (2 ex.).

Remarks.- This species has long anal fin and connected to the caudal fin at least at their base. The three specimens examined were caught at Pos Iskandar using a gill net in 1982. Mizuno and Furtado (1982) reported the species as *Prophagorus niewhofi.*

Family: Belonidae

***Xenentodon canciloides* (Bleeker, 1853)**

Plate 9d

Material examined.- UMKL 5782 (1 ex.), UMKL 5851 (4 ex.), UMKL 6006 (1 ex.), ZRC 3257 (14 ex.).

Remarks.- This species has an extremely elongated body. Recent specimens were caught at the surface areas of the open water near Tanjung Penarikan and Paya Jelawat.

Family: Hemiramphidae

***Hemirhamphodon pogonognathus* (Bleeker, 1853)**

Plate 9e

Material examined.- UMKL 5982 (7 ex.), UMKL 5988 (1 ex.), UMKL 6020 (5 ex.)

Remarks.- This species is normally seen swimming at the surface of the lake. A specimen labelled as *Zenarchopterus* sp. (ZRC 2683) probably refers to this species.

Family: Synbranchidae

***Monopterus albus* (Zuiew, 1793)**

Plate 9f

Material examined.- UMKL 6003 (2 ex.), ZRC 3169 (1 ex.).

Remarks.- This species preferred to stay in burrows in muddy areas (Zakaria-Ismail, 1987). They were caught using an electro-shocker near the shore of Kg. Pathir’s Jetty.

Family: Mastacembelidae

Macrognathus aculeatus (Bloch, 1786)

Plate 9g

Material examined.- UMKL 424 (1 ex.), UMKL 425 (1 ex.), UMKL 426 (3 ex.), UMKL 2621 (1 ex.), UMKL 6035 (1 ex.).

Remarks.- This species has long rostrum and obliquely bare colour pattern on the body. It is the most common mastacembelid eel in the area particularly in Paya Jelawat and Paya Tembangau.

Macrognathus maculatus (Cuvier *in* Cuvier & Valenciennes, 1832)

Plate 9h

Material examined.- UMKL 429 (1 ex.).

Remarks.- A specimen examined was caught in 1971. It is considered to have become extinct in the lake.

Mastacembelus favus Hora, 1923

Plate 10a

Material examined.- UMKL 5814 (1 ex.), UMKL 5865 (1 ex.).

Remarks.- It can be found in swampy areas of Tasek Bera.

Family: Ambassidae (Chandidae)

***Parambassis apogonoides* (Bleeker, 1851)**

Plate 10b

Material examined.- UMKL 5813 (1 ex.), UMKL 5841 (1 ex.), UMKL 5890 (1 ex.), ZRC 19603 (1 ex.).

Remarks.- It is normally found in open waters of the lake. The species was recorded for the first time by Roberts (1994) based on a specimen housed in the ZRC, Singapore.

***Parambassis siamensis* (Fraser-Bunner, 1954)**

Plate 10c

Material examined.- UMKL 2623 (1 ex.), UMKL 2906 (1 ex.), UMKL 3165 (2 ex.), UMKL 5840 (1 ex.).

Remarks.- It can be found in all types of habitats in Tasek Bera. Herre and Myers (1937) recorded this species as *Ambassis ranga* and Mizuno and Furtado (1982) listed it as *Chanda ranga*.

Family: Nandidae

***Nandus nebulosus* (Gray, 1835)**

Plate 10d

Material examined.- UMKL 361 (1 ex.), UMKL 5848 (4 ex.), UMKL 6017 (1 ex.), ZRC 360 (1 ex.), ZRC 3478 (40 ex.).

Remarks.- It was caught in areas covered with leaf litter. The species has wide distribution in Peninsular Malaysia although it is not very common (Zakaria-Ismail, 1993)

***Pristolepis fasciata* (Bleeker, 1793)**

Plate 10e

Material examined.- UMKL 366 (1 ex.), UMKL 367 (16 ex.), UMKL 368 (3 ex.), UMKL 2507 (1 ex.), UMKL 2775 (1 ex.), UMKL 2826 (11 ex.), UMKL 5784 (3 ex.), UMKL 5810 (1 ex.), UMKL 5820 (2 ex.), UMKL 5830 (1 ex.), UMKL 5842 (3 ex.), UMKL 5855 (2 ex.), UMKL 5903 (1 ex.), UMKL 6027 (2 ex.), ZRC 405 (1 ex.), ZRC 407 (20 ex.), ZRC 3479 (100 ex.), ZRC 8072-8073 (2 ex.), ZRC 8074 (1 ex.), ZRC 8075-8079 (5 ex.), ZRC 19594-19596 (3 ex.).

Remarks.- Specimens of the species were caught in all types of habitats in Tasek Bera using gill net and cast net.

Family: Eleotrididae

***Oxyeleotris marmorata* (Bleeker, 1852)**

Plate 10f

Material examined.- ZRC 8840 (1 ex.).

Remarks.- The species is rather common although it is not abundant in the lake.

Family: Anabantidae

***Anabas testudineus* (Bloch, 1792)**

Plate 10g

Material examined.- UMKL 376 (1 ex.), UMKL 5889 (1 ex.), ZRC 3468 (1 ex.).

Remarks.- The species is locally known as *puyu.* It is widely distributed in Malaysia particularly in paddy fields (Zakaria-Ismail, 1993).

Family: Helostomatidae

Helostoma temminkii Cuvier, 1829

Plate 10h

Material examined.- UMKL 2622 (1 ex.), UMKL 5827 (4 ex.).

Remarks.- This is a common species in swampy areas of the blackwater habitat in Selangor and Rompin (Zakaria-Ismail, 1993) but it does not seem to be common in Tasek Bera. Although the specific name has been widely spelled as *temminckii*, the original spelling proposed by Cuvier (1829) is followed.

Family: Osphronemidae

Belontia hasselti (Cuvier *in* Cuvier & Valenciennes, 1831)

Plate 11a

Material examined.- UMKL 5845 (5 ex.), UMKL 5997 (1 ex.), ZRC 425 (1 ex.), ZRC 429, ZRC 430 (9 ex.), ZRC 3469 (1 ex.).

Remarks.- It is commonly found in slow-moving waters in the lake. It was reported by Mizuno and Furtado (1982) as *Polyacanthus hasseltii*.

Betta pugnax (Cantor, 1849)

Plate 11b

Material examined.- UMKL 5844 (3 ex.), UMKL 6022 (1 ex.), ZRC 451 (3 ex.), ZRC 3476 (100 ex.).

Remarks.- It inhabits areas covered with plant near the shore of the lake.

***Betta waseri* Krummenacher, 1986**

Plate 11c

Material examined.- UMKL 5905 (2 ex.).

Remarks.- This species is found in areas covered with leaf litter and vegetation. It has not been recorded in previous surveys.

***Luciocephalus pulcher* (Gray, 1830)**

Plate 11d

Material examined.- UMKL 755 (1 ex.), UMKL 5846 (2 ex.), UMKL 5883 (1 ex.), UMKL 5901 (1 ex.), UMKL 6015 (3 ex.), ZRC 420 (2 ex.), ZRC 3477 (19 ex.).

Remarks.- The species prefers to rest on submerged roots of *Pandanus* plant a night. This is where most of the specimens were caught.

***Sphaerichthys osphromenoides* Canestrini, 1830**

Plate 11e

Material examined.- UMKL 3180 (2 ex.), UMKL 5847 (1 ex.),UMKL 6012 (1 ex.).

Remarks.- It was caught in shallow waters overgrown by aquatic plants near the shore of Kg. Pathir.

***Trichogaster leerii* (Bleeker, 1852)**

Plate 11f

Material examined.- UMKL 380 (1 ex.), UMKL 778 (7 ex.), UMKL 3164 (1 ex.), UMKL 5838 (4 ex.), UMKL 5853 (1 ex.), UMKL 5995 (2 ex.), UMKL 6024 (7 ex.), ZRC 8099-8100 (2 ex.), ZRC 3473 (1ex.).

Remarks.- It was caught in the areas overgrown with aquatic plants near the shore.

***Trichogaster trichopterus* (Pallas, 1770)**

Plate 11g

Material examined.- UMKL 389 (1 ex.), UMKL 786 (12 ex.), UMKL 2900 (1 ex.), UMKL 5839 (1 ex.),UMKL 5996 (1 ex.), ZRC 1959 (1 ex.), ZRC 3475 (2 ex.), ZRC 8085-8098 (14 ex.).

Remarks.- This gourami is very common in the lake and throughout Peninsular Malaysia (Zakaria-Ismail, 1993).

***Trichopsis vittata* (Cuvier *in* Cuvier & Valenciennes, 1831)**

Plate 11h

Material examined.- UMKL 3172 (8 ex.), UMKL 3183 (4 ex.), UMKL 5843 (9 ex.), UMKL 5904 (3 ex.), ZRC 3472 (100 ex.), ZRC 19598 (1 ex.).

Remarks.- It was found in shallow parts of Paya Tembangau. The area is overgrown with aquatic plants especially the *Lepironia* reed.

***Osphronemus goramy* Lacepède, 1801**

Plate 12a

Material examined.- UMKL 5815 (1 ex.), UMKL 5859 (1 ex.).

Remarks.- It is a common species at Tasek Bera. Known as *kalui* by local people, members of the species were caught at open waters surrounded with *Pandanus* plant.

Family: Channidae

Channa lucius (Cuvier *in* Cuvier & Valenciennes, 1831)

Plate 12b

Material examined.- UMKL 3175 (1 ex.),UMKL 5816 (1 ex.), UMKL 5993 (1 ex.), UMKL 6123 (1 ex.), ZRC 2833 (1 ex.), ZRC 284e (1 ex.), ZRC 3481 (3 ex.), ZRC 8048 (1 ex.), ZRC 8051 (1 ex.), ZRC 8052 (1 ex.), ZRC 8848 (1 ex.), ZRC 9168 (1 ex.).

Remarks.- It is common in shallow waters of the lake.

Channa melasoma (Bleeker, 1851)

Plate 12c

Material examined.- UMKL 2619 (1 ex.), ZRC 2837 (1 ex.).

Remarks.- These two specimens are the only proof of the presence of the species in the lake.

Channa micropeltes (Cuvier *in* Cuvier & Valenciennes,1831)

Plate 12d

Material examined.- UMKL 5785 (1 ex.), UMKL 5817 (1 ex.), ZRC 2847 (1ex.), ZRC 2848 (1 ex.), ZRC 7963 (1 ex.), ZRC 7989 (1 ex.), ZRC 8815 (1 ex.).

Remarks.- This *Channa* is common in open-water areas of the swamp. It is the largest of all snakeheads in Peninsular Malaysia (Zakaria-Ismail, 1993).

***Channa striata* (Bloch, 1793)**

Plate 12e

Material examined.- UMKL 5994 (2 ex.), ZRC 5638 (1 ex.), ZRC 8047 (1 ex.), ZRC 8050 (1 ex.), ZRC 8056 (1 ex.).

Remarks.- The most common *Channa* in Tasek Bera and also throughout much of Peninsular Malaysia (Zakaria-Ismail, 1993). Most of the specimens were caught with gill net near Pos Iskandar.

Family: Soleidae

***Achiroides leucorhynchos* Bleeker, 1851**

Plate 12f

Material examined.- UMKL 5870 (1 ex.), ZRC 2329 (1 ex.).

Remarks.- This small species was caught in shallow waters near Teluk Gedubang which has a sandy bottom substrate. Mizuno and Furtado (1982) misdentified it as *Synaptura harmandi.* A specimen from ZRC labelled as *Achiroides achira* is refers to this species.

Family: Tetraodontidae

***Monotrete palembangensis* Bleeker, 1852**

Plate 12g

Material examined.- UMKL 5800 (1 ex.), ZRC 1985 (1 ex.), ZRC 2316 (1 ex.).

Remarks.- They have the ability to inflate their body by swallowing air or water. The present specimen was caught near Lubuk Salleh, one of the deepest parts in Tasek Bera.

3.4 RESULTS AND DISCUSSION

A total of 95 species of fish belonging to 22 families were recorded in Tasek Bera Wetland (Table 3.1) in the current survey based on field collection and inspection of museum specimens in UMKL and ZRC. Forty species (43%) were cyprinids, the most dominant group not only in the lake but also throughout much of Peninsular Malaysia (Zakaria-Ismail, 1994 & 1998). Four species recorded were based on only one museum specimen each; they are *Amblyrhynchichthys truncatus*, *Balantiocheilos melanopterus, Barbichthys laevis* and *Epalzeorhynchos kalopterus***.** Fourteen species are new records for the wetland; they include *Acanthopsoides molobrion, Akysis alfredi, Amblyrhynchichthys truncatus, Betta waseri*, *Boraras maculatus, Channa gachua, Chela laubuca, Epalzeorhynchos kalopterus, Kryptopterus moorei, Lepidocephalichthys furcatus***,** *Macrochirichthys macrochirus, Macrognathus maculates, Osteochilus microcephalus,* and *Pangio malayana*. Of the cyprinids, *Cyclocheilichthys apogon* and *Labiobarbus festivus* seem to be the most common and abundant species. They were normally caught in large numbers from all kinds of microhabitats of the swamp.

The endangered and expensive ornamental fish, *Scleropages formosus* of the family Osteoglossidae or known as *ikan kelisa* among the Malays, still exists in the wetland. The Semelai, indigenous people that live around the lake, have been catching the fries for many years. The fries are normally caught from September to December every year and sold to fish collectors for about RM80.00 per individual, which are about 10 to 15 cm in total length. *Botia hymenophysa* from the family Cobitidae was recorded as a dominant species by Mizuno and Furtado (1982), but is now difficult to find. In the present study, the species was caught only in Paya Tembangau by local fisherman using hook and line baited with worms. In Peninsular Malaysia, this cobitid fish has limited distribution (Zakaria-Ismail, 1993 and 1994). The swamp eel, *Monopterus albus* of the family Synbranchidae, was caught only by electro-shocker at the area nearby the shore of Kg. Pathir's Jetty. The muddy substrate of the jetty seems to be a favourable habitat for the species. Only one individual of the freshwater sole*, Achiroides leucorhynchos* of the family Soleidae, was caught using a dip net in the wetland at the sampling site near Teluk Gedubang, which has small areas of sandy shore. Mizuno and Furtado (1982) misdentified it as *Synaptura harmandi.*

Giant freshwater puffer, *Monotrete palembangensis* of the family Tetraodontidae, is one of the unusual fishes found in the area. They are able to inflate their body forming a balloon by swallowing air or water. Coupled with the presence of poison in their flesh, the species are able to avoid many predators including man (Zakaria-Ismail, 1991c). Only one specimen was preserved in UMKL, was given by a local fisherman who caught it using a gill net. A specimen of *Hemibagrus wyckii* (ZRC 8802) from the family Bagridae and *Chonerhinus modestus* (ZRC 1308) from the family Tetraodontidae was supposedly housed in the ZRC. However, the specimens could not be located in the museum.

Based on the recent study, four species were considered to be locally extinct, while 39 and 27 species respectively, were considered to be extremely rare and rare. Twenty species of fishes were common and only five species were considered abundant based on the ranking applied using the number of specimens caught during the recent sampling (Table 3.1). While the compilation of past records and current status listed a total of 144 species in Tasek Bera, these included several redundant species due to identification issues including eight species with only genus names making confirmation impossible as specimens from the previous surveys were not available to be examined. While the current study recorded 95 species with 14 new records, it should be noted that Sim (2002) had previously recorded 94 species. A comparison of the species list showed six species in the earlier study was not recorded in the current study. In addition, 11 species from Mizuno and Furtado (1982) was not recorded in the current study. Although Khan (1996) had only listed 42 species, he managed to record six species which were not recorded by other authors.

Tasek Bera wetland is a Ramsar site in recognition of it as a wetland of international importance. Its status as a conservation area should ensure the perpetuation of many fish species, particularly the endangered Malayan bonytongue and other rare fishes of Peninsular Malaysia. Unfortunately, land clearing around the wetland is taking place at an unprecedented rate for rubber and oil palm plantations. The management authority of Tasek Bera has to play a bigger role in implementing the Integrated Management Plan of this Ramsar site without compromising the ecosystem and the wellbeing of the native Semelai community inhabiting the area.

Table 3.1 Status of the 95 species known to occur in Tasek Bera, Pahang, Malaysia based on present sampling efforts. (Abundant – There are more than ten individuals caught from the recent sampling; Common – There are between five to ten individuals caught from the recent sampling; Rare – Occasionally caught from the recent sampling; Extremely rare – One or no individual was sampled in recent studies; Locally extinct – Any species which has not been recorded for the last 30 years is considered to have become locally extinct)

No.	Family	Species	Existence Status
1.	**Osteoglossidae**	*Scleropages formosus*	Extremely rare
2.	**Notopteridae**	*Chitala lopis*	Rare
3.		*Notopterus notopterus*	Abundant
4.	**Cyprinidae**	*Amblyrhynchichthys truncates*	Extremely rare
5.		*Balantiocheilos melanopterus*	Locally extinct
6.		*Barbichthys laevis*	Extremely rare
7.		*Barbonymus schwanenfeldii*	Common
8.		*Boraras maculatus*	Rare
9.		*Chela laubuca*	Extremely rare
10.		*Cyclocheilichthys apogon*	Abundant
11.		*Cyclocheilichthys heteronema*	Rare
12.		*Cyclocheilichthys repasson*	Extremely rare
13.		*Epalzeorhynchos kalopterus*	Locally extinct
14.		*Hampala macrolepidota*	Common
15.		*Labiobarbus festivus*	Abundant
16.		*Labiobarbus leptocheilus*	Rare
17.		*Labiobarbus ocellatus*	Extremely rare
18.		*Leptobarbus hoevenii*	Rare
19.		*Luciosoma setigerum*	Rare
20.		*Luciosoma trinema*	Rare
21.		*Macrochirichthys macrochirus*	Locally extinct
22.		*Osteochilus hasseltii*	Abundant
23.		*Osteochilus melanopleurus*	Rare
24.		*Osteochilus microcephalus*	Extremely rare
25.		*Osteochilus spilurus*	Extremely rare
26.		*Osteochilus waandersii*	Rare
27.		*Oxygaster anomalura*	Common
28.		*Parachela hypopthalmus*	Rare
29.		*Parachela oxygastroides*	Rare
30.		*Puntioplites bulu*	Rare
31.		*Puntius binotatus*	Rare
32.		*Puntius johorensis*	Common
33.		*Puntius lineatus*	Extremely rare
34.		*Puntius partipentazona*	Abundant
35.		*Rasbora cephalotaenia*	Common
36.		*Rasbora dorsiocellata*	Common
37.		*Rasbora dusonensis*	Common
38.		*Rasbora einthovenii*	Common
39.		*Rasbora elegans*	Rare
40.		*Rasbora pauciperforata*	Extremely rare
41.		*Rasbora pauciqualis*	Extremely rare
42.		*Thynnichthys thynnoides*	Common
43.		*Trigonostigma heteromorpha*	Rare

Table 3.1(continued) Status of the 95 species known to occur in Tasek Bera, Pahang, Malaysia based on present sampling efforts. (Abundant – There are more than ten individuals caught from the recent sampling; Common – There are between five to ten individuals caught from the recent sampling; Rare – Occasionally caught from the recent sampling; Extremely rare – One or no individual was sampled in recent studies; Locally extinct – Any species which has not been recorded for the last 30 years is considered to have become locally extinct)

No.	Family	Species	Existence Status
44.	**Cobitidae**	*Acanthopsoides molobrion*	Extremely rare
45.		*Botia hymenophysa*	Extremely rare
46.		*Lepidocephalichthys furcatus*	Extremely rare
47.		*Pangio malayana*	Extremely rare
48.		*Pangio semicincta*	Extremely rare
49.		*Pangio shelfordii*	Extremely rare
50.	**Balitoridae**	*Nemacheilus selangoricus*	Extremely rare
51.	**Bagridae**	*Hemibagrus bleekeri*	Common
52.		*Leoicassis poecilopterus*	Extremely rare
53.		*Mystus singaringan*	Rare
54.	**Siluridae**	*Kryptopterus apogon*	Common
55.		*Kryptopterus bicirrhis*	Extremely rare
56.		*Kryptopterus limpok*	Common
57.		*Krpytopterus macrocephalus*	Rare
58.		*Krpytopterus moorei*	Rare
59.		*Ompok eugieneatus*	Rare
60.		*Ompok fumidus*	Rare
61.		*Ompok hypopthalmus*	Common
62.		*Silurichthys hasseltii*	Extremely rare
63.		*Wallago leerii*	Extremely rare
64.	**Akysidae**	*Akysis alfredi*	Extremely rare
65.	**Clariidae**	*Clarias batrachus*	Extremely rare
66.		*Clarias meladerma*	Extremely rare
67.		*Clarias nieuhofii*	Extremely rare
68.	**Hemirhamphida**	*Hemirhamphodon pogonognathus*	Common
69.	**Belonidae**	*Xenentodon canciloides*	Common
70.	**Synbranchidae**	*Monopterus albus*	Rare
71.	**Mastacembelidae**	*Macrognathus aculeatus*	Extremely rare
72.		*Macrognathus maculatus*	Locally extinct
73.		*Mastacembelus favus*	Extremely rare
74.	**Ambassidae**	*Parambassis apogonoides*	Extremely rare
75.		*Parambassis siamensis*	Extremely rare
76.	**Nandidae**	*Nandus nebulosus*	Extremely rare
77.		*Pristolepis fasciata*	Common
78.	**Eleotridae**	*Oxyeleotris marmorata*	Extremely rare
79.	**Anabantidae**	*Anabas testudineus*	Extremely rare
80.	**Helostomatidae**	*Helostoma temminkii*	Rare
81.	**Osphronemidae**	*Belontia hasselti*	Rare
82.		*Betta pugnax*	Rare
83.		*Betta waseri*	Rare
84.		*Luciocephalus pulcher*	Rare
85.		*Sphaerichthys osphromenoides*	Extremely rare
86.		*Trichogaster leerii*	Common
87.		*Trichogaster trichopterus*	Common
88.		*Trichopsis vittata*	Common
89.		*Osphronemus goramy*	Rare

Table 3.1(continued) Status of the 95 species known to occur in Tasek Bera, Pahang, Malaysia based on present sampling efforts. (Abundant – There are more than ten individuals caught from the recent sampling; Common – There are between five to ten individuals caught from the recent sampling; Rare – Occasionally caught from the recent sampling; Extremely rare – One or no individual was sampled in recent studies; Locally extinct – Any species which has not been recorded for the last 30 years is considered to have become locally extinct)

No.	Family	Species	Existence Status
90.	**Channidae**	*Channa lucius*	Common
91.		*Channa melasoma*	Extremely rare
92.		*Channa micropeltes*	Extremely rare
93.		*Channa striata*	Extremely rare
94.	**Soleidae**	*Achiroides leucorhynchos*	Extremely rare
95.	**Tetraodontidae**	*Monotrete palembangensis*	Extremely rare

Table 3.2 Checklist of fishes in Tasek Bera from previous and present studies. Symbol " ✓" means the species was recorded and "✗" means not recorded by the particular authors.

No.	Family	Species	Mizuno and Furtado (1982)	Khan *et al.* (1996)	Sim (2002)	Present study (2007)	Notes
1.	**Osteoglossidae**	*Scleropages formosus*	✓	✓	✓	✓	
2.	**Notopteridae**	*Chitala lopis*	✓	✗	✓	✓	Mizuno and Furtado (1982) recorded as *Notopterus chitala*
3.		*Notopterus notopterus*	✓	✓	✓	✓	
4.	**Clupeidae**	**Clupeichtys aesarnensis*	✗	✓	✓	✗	Doubtful occurance
5.	**Cyprinidae**	*Amblyrhynchichthys truncatus*	✗	✗	✗	✓	New record for Tasek Bera
6.		*Balantiocheilos melanopterus*	✗	✗	✓	✓	
7.		*Barbichthys laevis*	✗	✓	✓	✓	
8.		*Barbonymus schwanenfeldii*	✓	✓	✓	✓	Previously known as *Puntius schwanenfeldii*
9.		*Boraras maculatus*	✗	✗	✗	✓	Previously known as *Rasbora maculates.* New record for Tasek Bera.
10.		*Chela laubuca*	✗	✗	✗	✓	New record for Tasek Bera
11.		*Chela* sp.	✓	✗	✗	✗	
12.		*Crossocheilus oblongus*	✗	✗	✓	✗	
13.		*Cyclocheilichthys apogon*	✓	✓	✓	✓	
14.		*Cyclocheilichthys armatus*	✓	✗	✓	✗	
15.		*Cyclocheilichthys heteronema*	✓	✗	✓	✓	
16.		*Cyclocheilichthys repasson*	✗	✓	✓	✓	
17.		*Epalzeorhynchos kalopterus*	✗	✗	✗	✓	New record for Tasek Bera
18.		*Hampala macrolepidota*	✓	✓	✓	✓	

Table 3.2(continued) Checklist of fishes in Tasek Bera from previous and present studies. Symbol " ✓" means the species was recorded and "✘" means not recorded by the particular authors.

19.		*Labiobarbus festivus*	✓	✓	✓	✓	Mizuno and Furtado (1982) recorded as *Labiobarbus faestiva*
20.		*Labiobarbus leptocheilus*	✘	✘	✓	✓	
21.		*Labiobarbus lineatus*	✘	✓	✘	✘	
22.		*Labiobarbus ocellatus*	✘	✓	✓	✓	
23.		*Labiobarbus* sp.	✘	✓	✘	✘	
24.		*Leptobarbus hoevenii*	✓	✘	✓	✓	
25.		*Luciosoma setigerum*	✓	✘	✓	✓	
26.		*Luciosoma trinema*	✓	✘	✓	✓	
27.		*Macrochirichthys macrochirus*	✘	✘	✘	✓	New record for Tasek Bera
28.		*Osteochilus hasseltii*	✓	✓	✓	✓	
29.		*Osteochilus melanopleurus*	✓	✘	✓	✓	
30.		*Osteochilus microcephalus*	✘	✘	✘	✓	New record for Tasek Bera
31.		*Osteochilus spilurus*	✓	✘	✓	✓	
32.		*Osteochilus* sp.	✘	✓	✘	✘	
33.		*Osteochilus vittatus*	✓	✘	✘	✘	
34.		*Osteochilus waandersii*	✘	✘	✓	✓	
35.		*Oxygaster anomalura*	✓	✓	✓	✓	
36.		*Parachela hypopthalmus*	✓	✘	✓	✓	Mizuno and Furtado (1982) recorded as *Oxygaster hypopthalmus*
37.		*Parachela oxygastroides*	✓	✘	✓	✓	Previously known as *Oxygaster oxygastroides*
38.		*Puntioplites bulu*	✓	✓	✓	✓	Mizuno and Furtado (1982) recorded as *Puntius bulu*
39.		*Puntius binotatus*	✓	✘	✓	✓	

Table 3.2(continued) Checklist of fishes in Tasek Bera from previous and present studies. Symbol " ✓" means the species was recorded and "✘" means not recorded by the particular authors.

40.		*Puntius eugrammus*	✓	-	-	-	Currently known as *Puntius johorensis*
41.		*Puntius johorensis*	✓	✓	✓	✓	Mizuno and Furtado (1982) recorded as *P. eugrammus* and *P. fasciatus*
42.		*Puntius lateristriga*	✓	✘	✓	✘	
43.		*Puntius lineatus*	✘	✘	✓	✓	
44.		*Puntius partipentazona*	✓	✓	✓	✓	Mizuno and Furtado (1982) recorded as *Tetrazona tetrazona* and *Puntius tetrazona partipentazona*
45.		*Puntius tetrazona partipentazona*	✓	-	-	-	Currently known as *Puntius partipentazona*
46.		*Rasbora argyrotaenia*	✓	✘	✘	✘	
47.		*Rasbora caudimaculata*	✓	✘	✓	✘	
48.		*Rasbora cephalotaenia*	✓	✘	✓	✓	
49.		*Rasbora dorsiocellata*	✓	✓	✓	✓	
50.		*Rasbora dusonensis*	✓	✓	✓	✓	Mizuno and Furtado (1982) also recorded as *R. myersi*
51.		*Rasbora einthovenii*	✓	✘	✘	✓	
52.		*Rasbora elegans*	✓	✘	✓	✓	
53.		* *Rasbora leptosoma*	✓	✘	✘	✘	Doubtful occurance
54.		*Rosbora pauciperforata*	✓	✘	✓	✓	
55.		*Rasbora pauciqualis*	✘	✘	✓	✓	Previously *known* as *Rasbora bankanensis*
56.		*Rasbora paviei*	✓	✘	✓	✘	Mizuno and Furtado (1982) and Sim (2002) recorded as *Rasbora sumatrana*

Table 3.2(continued) Checklist of fishes in Tasek Bera from previous and present studies. Symbol " ✓" means the species was recorded and "✗" means not recorded by the particular authors.

57.		*Rasbora retrodorsalis*	✓	✗	✗	✗	Currently known as *Rasbora aurotaenia*
58.		*Rasbora* sp.	✗	✓	✗	✗	
59.		*Rasbora gracilis*	✓	✗	✗	✗	Mizuno and Furtado (1982) also recorded as *R. taeniata*
60.		*Rasbora myersi*	✓	-	-	-	Currently known as *Rasbora dusonensis*
61.		*Rasbora trilineata*	✓	✗	✓	✗	
62.		*Thynnichthys thynnoides*	✗	✗	✓	✓	
63.		**Tor clouremis*	✓	✗	✗	✗	Doubtful occurance
64.		*Trigonostigma heteromorpha*	✓	✗	✓	✓	Mizuno and Furtado (1982) recorded as *Rasbora heteromorpha*
65.	**Cobitidae**	*Acanthopsoides molobrion*	✗	✗	✗	✓	New record for Tasek Bera
66.		*Botia hymenophysa*	✓	✗	✗	✓	
67.		*Lepidocephalichthys furcatus*	✗	✗	✗	✓	New record for Tasek Bera
68.		*Pangio kuhlii*	✗	✓	✓	✗	
69.		*Pangio malayana*	✗	✗	✗	✓	New record for Tasek Bera
70.		*Pangio muraeniformis*	✗	✓	✗	✗	
71.		*Pangio semicincta*	✓	✗	✗	✓	Mizuno and Furtado (1982) recorded as *Acanthophthalmus kuhli*
72.		*Pangio shelfordii*	✗	✗	✓	✓	
73.	**Balitoridae**	*Homaloptera nebulosa*	✗	✓	✗	✗	
74.		*Homaloptera ogilviei*	✗	✓	✓	✗	
75.		*Nemacheilus selangoricus*	✓	✗	✓	✓	

Table 3.2(continued) Checklist of fishes in Tasek Bera from previous and present studies. Symbol " ✓" means the species was recorded and "✗" means not recorded by the particular authors.

76.		**Vaillantella flavofasciata*	✓	✗	✗	✗	Doubtful occurance
77.		*Vaillantella maassi*	✗	✗	✓	✗	
78.	**Bagridae**	*Hemibagrus bleekeri*	✓	✓	✓	✓	Previously known as *Mystus nemurus*
79.		*Pseudomystus leiacanthus*	✓	✗	✓	✗	Previously in genus *Leiocassis*
80.		*Leiocassis micropogon*	✓	✗	✓	✗	
81.		*Leoicassis poecilopterus*	✓	✗	✓	✓	Previously known as *Leiocassis baramensis*
82.		*Mystus cavasius*	✓	-	-	-	Currently known as *Mystus singaringan.*
83.		*Mystus singaringan*	✓	✓	✓	✓	Mizuno and Furtado (1982) recorded as *Mystus cavasius.* Previously known as *Mystus macronemus* or *Mystus nigriceps.*
84.	**Siluridae**	*Kryptopterus apogon*	✓	✗	✓	✓	
85.		*Kryptopterus bicirrhis*	✓	✗	✓	✓	
86.		*Kryptopterus limpok*	✓	✗	✓	✓	
87.		*Krpytopterus macrocephalus*	✗	✓	✗	✓	
88.		*Kryptopterus moorei*	✗	✗	✗	✓	New record for Tasek Bera
89.		*Ompok eugeneitus*	✗	✗	✓	✓	
90.		*Ompok fumidus*	✓	✗	✓	✓	Mizuno and Furtado (1982) recorded as *Ompok leiacanthus*
91.		*Ompok hypopthalmus*	✓	✓	✓	✓	Mizuno and Furtado (1982) recorded as *Silurodes hypopthalmus*
92.		*Ompok* sp.	✗	✓	✗	✗	
93.		*Silurichthys hasseltii*	✓	✗	✓	✓	

Table 3.2(continued) Checklist of fishes in Tasek Bera from previous and present studies. Symbol " ✓" means the species was recorded and "✗" means not recorded by the particular authors.

94.		*Wallago leerii*	✗	✗	✓	✓	
95.		*Wallagonia miostoma*	✓	✗	✗	✗	Doubtful occurance
96.	**Akysidae**	*Akysis alfredi*	✗	✗	✗	✓	New record for Tasek Bera
97.	**Sisoridae**	*Glyptothorax fuscus*	✓	✗	✓	✗	Mizuno and Furtado (1982) and Sim (2002) recorded as *G. major*
98.	**Parakysidae**	*Parakysis verrucosa*	✓	✗	✓	✗	
99.	**Chacidae**	*Chaka bankanensis*	✓	✗	✓	✗	Mizuno and Furtado (1982) recorded as *Chaka chaka*
100.	**Clariidae**	*Clarias batrachus*	✓	✗	✓	✓	
101.		*Clarias meladerma*	✓	✗	✓	✓	
102.		*Clarias nieuhofii*	✓	✗	✓	✓	Mizuno and Furtado (1982) recorded as *Prophagorus niewhofi*
103.	**Synbranchidae**	*Monopterus albus*	✓	✗	✓	✓	Mizuno and Furtado (1982) recorded as *Fluta alba*
104.	**Mastacembelidae**	*Macrognathus aculeatus*	✓	✗	✓	✓	
105.		*Macrognathus maculatus*	✗	✗	✗	✓	New record for Tasek Bera
106.		*Mastacembelus favus*	✗	✓	✓	✓	
107.	**Chandidae (Ambassidae)**	*Chanda ranga*	✓	✗	✗	✗	Currently accepted name is *Pseudambassis ranga*
108.		*Chanda* sp.	✓	✗	✗	✗	
109.		*Parambassis apogonoides*	✗	✗	✓	✓	
110.		*Parambassis punctulatus*	✗	✓	✗	✗	
111.		*Parambassis siamensis*	✗	✗	✓	✓	Mizuno and Furtado (1982) recorded as *Chanda ranga* and Khan *et al.* (1996) recorded as *Parambasis punctulatus.*

Table 3.2(continued) Checklist of fishes in Tasek Bera from previous and present studies. Symbol " ✓" means the species was recorded and "✗" means not recorded by the particular authors.

112.		*Parambassis* sp.	✗	✓	✗	✗	
113.		*Gymnochanda filamentosa*	✓	✗	✗	✗	Mizuno and Furtado (1982) recorded as *Gynochanda filamentosa*
114.	**Nandidae**	*Nandus nebulosus*	✓	✗	✓	✓	
115.		*Pristolepis fasciata*	✓	✓	✓	✓	
116.		*Pristolepis grootii*	✗	✓	✗	✗	
117.	**Eleotridae**	*Oxyeleotris marmorata*	✓	✗	✓	✓	Mizuno and Furtado (1982) recorded as *O. marmoratus*
118.	**Anabantidae**	*Anabas testudineus*	✓	✗	✓	✓	
119.	**Helostomatidae**	*Helostoma temminckii*	✓	✗	✓	✓	
120.	**Osphronemidae**	*Belontia hasselti*	✓	✗	✓	✓	Mizuno and Furtado (1982) recorded as *Polyacanthus hasseltii*.
121.		*Betta pugnax*	✓	✗	✓	✓	
122.		*Betta splendens*	✓	✗	✗	✗	
123.		*Betta waseri*	✗	✗	✗	✓	New record for Tasek Bera
124.		*Luciocephalus pulcher*	✓	✗	✓	✓	
125.		*Polyacanthus hasseltii*	✓	✗	✗	✗	
126.		*Sphaerichthys osphromenoides*	✓	✗	✓	✓	
127.		*Trichogaster leerii*	✓	✗	✓	✓	
128.		*Trichogaster pectoralis*	✓	✗	✓	✗	
129.		*Trichogaster trichopterus*	✓	✗	✓	✓	
130.		*Trichopsis vittata*	✓	✓	✓	✓	
131.		*Osphronemus goramy*	✓	✓	✓	✓	

Table 3.2(continued) Checklist of fishes in Tasek Bera from previous and present studies. Symbol " ✓" means the species was recorded and "✗" means not recorded by the particular authors.

132.	**Channidae**	*Channa gachua*	✗	✗	✗	✓	New record for Tasek Bera
133.		*Channa lucius*	✓	✓	✓	✓	
134.		*Channa maruloides*	✓	✗	✗	✗	
135.		*Channa melasoma*	✗	✗	✓	✗	
136.		*Channa micropeltes*	✓	✓	✓	✓	
137.		*Channa striata*	✓	✗	✓	✓	
138.		*Channa* sp.	✗	✓	✗	✗	
139.	**Belonidae**	*Belone canala*	✓	-	-	-	Currently known as *Xenentodon conciloides*
140.		*Xenentodon canciloides*	✓	✓	✓	✓	Mizuno and Furtado (1982) recorded as *Belone canala*
141.	**Hemirhamphidae**	*Hemirhamphodon pogonognathus*	✓	✗	✓	✓	
142.	**Syngnathidae**	*Doryichthys deokhatoides*	✗	✗	✓	✗	
143.	**Soleidae**	*Achiroides leucorhynchos*	✓	✗	✗	✓	Mizuno and Furtado (1982) recorded as *Synaptura harmandi*
144.	**Tetraodontidae**	*Monotrete palembangensis*	✓	✓	✓	✓	Previously known as *Tetraodon palembangensis*
Total			**95**	**42**	**94**	**95**	

Plate 1a *Scleropages formosus* (SL 95 mm)

Plate 1b *Chitala lopis* (SL 720 mm)

Plate 1c *Notopterus notopterus* (SL 130 mm)

Plate 1d *Amblyrhynchichthys truncates* (SL 64 mm)

Plate 1e *Balantiocheilos melanopterus* (SL 180 mm)

Plate 1f *Barbichthys laevis* (SL 83 mm)

Plate 1g *Barbonymus schwanenfeldii* (SL 154mm)

Plate 1h *Boraras maculatus* (SL17 mm)

Plate 1

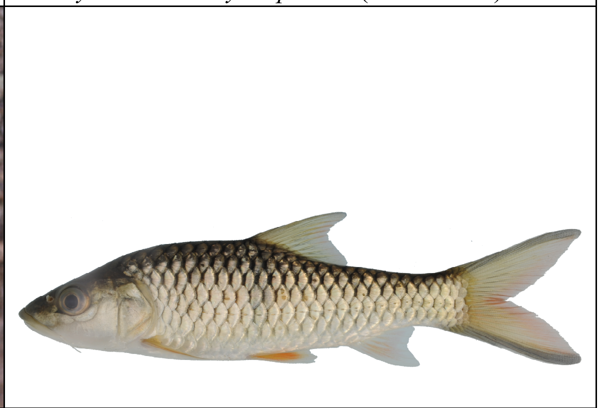
2a *Chela laubuca* (SL 50 mm)

2b *Cyclocheilichthys apogon* (SL 95 mm)

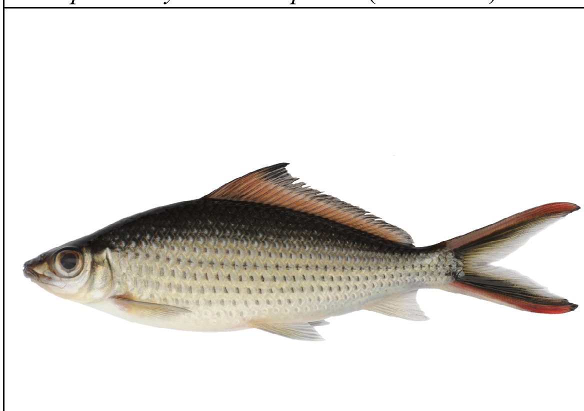
2c *Cyclocheilichthys heteronema* (SL 78 mm)

2d *Cyclocheilichthys repasson* (SL 120 mm)

2e *Epalzeorhynchos kalopterus* (SL 83 mm)



2f *Hampala macrolepidota* (SL 75 mm)

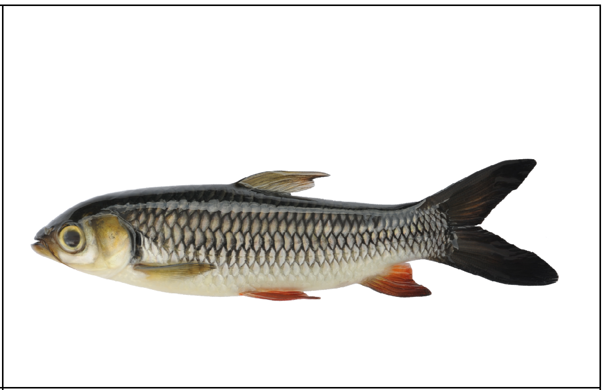


2g *Labiobarbus festivus* (SL 135 mm)

2h *Labiobarbus leptocheilus* (SL 125 mm)

Plate 2

3a *Labiobarbus ocellatus* (SL 124 mm)



3b *Leptobarbus hoevenii* (SL 112 mm)

3c *Luciosoma setigerum* (SL 122 mm)

3d *Luciosoma trinema* (SL 98 mm)

3e *Macrochirichthys macrochirus* (SL 152 mm)

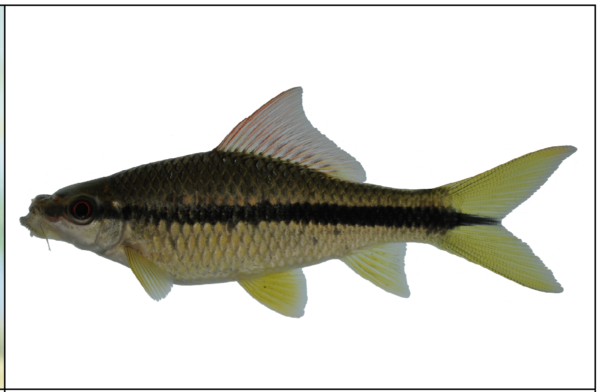
3f *Osteochilus hasseltii* (SL 143 mm)

3g *Osteochilus melanopleurus* (SL 250 mm)

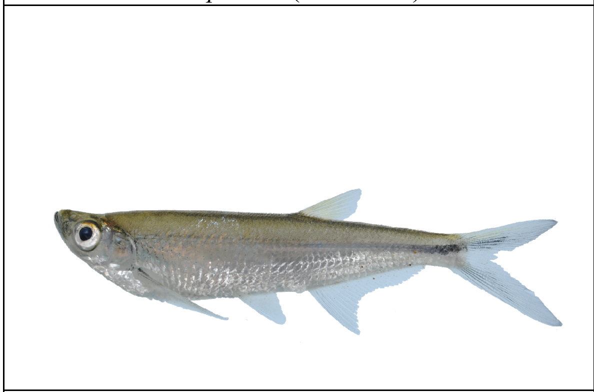
3h *Osteochilus microcephalus* (SL 140 mm)

Plate 3

4a *Osteochilus spilurus* (SL 93 mm)



4b *Osteochilus waandersii* (SL 130 mm)

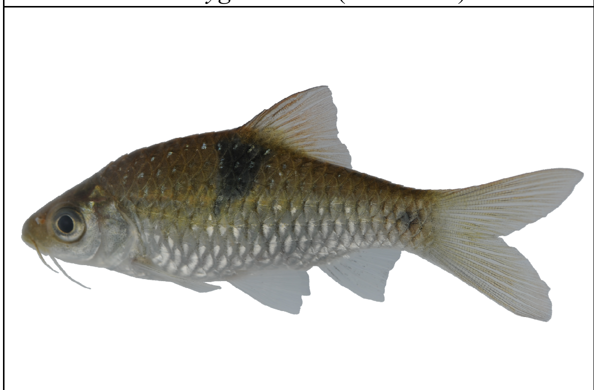


4c *Oxygaster anomalura* (SL 65 mm)

4d *Parachela hypopthalmus* (SL 25 mm)

4e *Parachela oxygastroides* (SL 32 mm)

4f *Puntioplites bulu* (SL 125 mm)



4g *Puntius binotatus* (SL 65 mm)

4h *Puntius johorensis* (SL 45 mm)

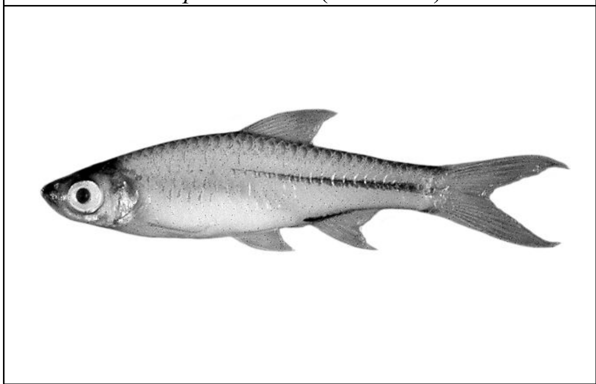
Plate 4

5a *Puntius lineatus* (SL 42 mm)

5b *Puntius partipentazona* (SL 25 mm)

5c *Rasbora cephalotaenia* (SL 45mm)

5d *Rasbora dorsiocellata* (SL 23 mm)



5e *Rasbora dusonensis* (SL 34 mm)

5f *Rasbora einthovenii* (SL 25 mm)

5g *Rasbora elegans* (SL 43 mm)

5h *Rasbora pauciperforata* (SL 21 mm)

Plate 5

6a *Rasbora pauciqualis* (SL 22 mm)

6b *Thynnichthys thynnoides* (SL 95 mm)

6c *Trigonostigma heteromorpha* (SL 23 mm)

6d *Acanthopsoides molobrion* (SL 45 mm)

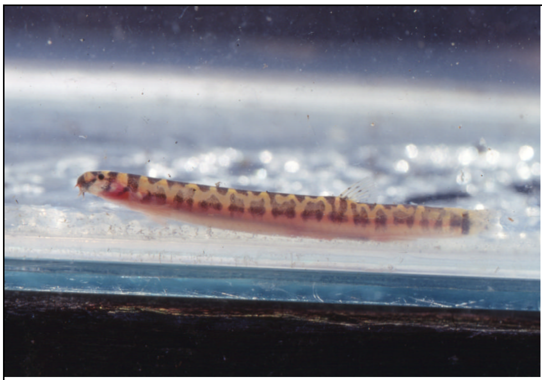
6e *Botia hymenophysa* (SL 86 mm)

6f *Lepidocephalichthys furcatus* (SL 25 mm)

6g *Pangio malayana* (SL 20 mm)

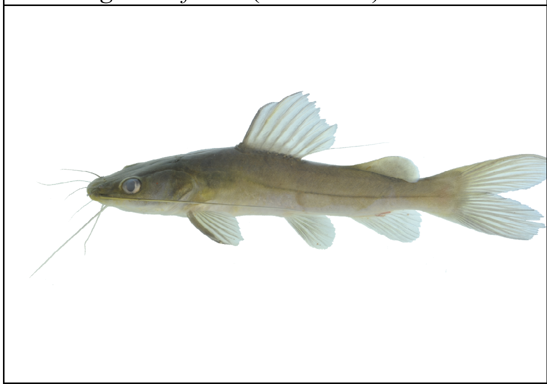
6h *Pangio semicincta* (SL 24-25 mm)

Plate 6



7a *Pangio shelfordii* (SL 28 mm)

7b *Nemacheilus selangoricus* (SL 28 mm)



7c *Hemibagrus bleekeri* (SL 134 mm)

7d *Leoicassis poecilopterus* (SL 34 mm)

7e *Mystus singaringan* (SL 72 mm)

7f *Kryptopterus apogon* (SL 91 mm)

7g *Kryptopterus bicirrhis* (SL 85 mm)

7h *Kryptopterus limpok* (SL 168 mm)

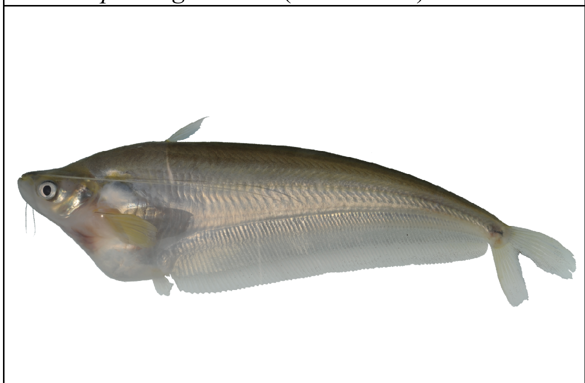
Plate 7

8a *Krpytopterus macrocephalus* (SL 112 mm)

8b *Krpytopterus moorei* (SL 103 mm)

8c *Ompok eugieneatus* (SL 124 mm)

8d *Ompok fumidus* (SL 121 mm)



8e *Ompok hypopthalmus* (SL 95 mm)

8f *Silurichthys hasseltii* (SL 85 mm)

8g *Wallago leerii* (SL 92 mm)

8h *Akysis alfredi* (SL 32 mm)

Plate 8

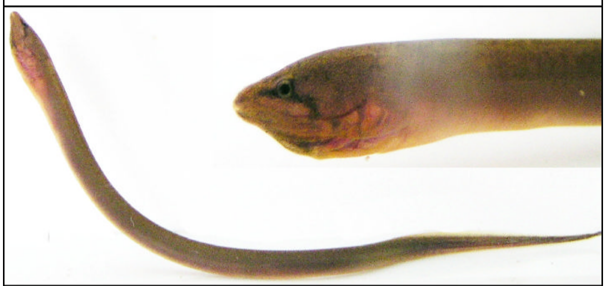
9a *Clarias batrachus* (SL 130 mm)

9b *Clarias meladerma* (SL 148 mm)

9c *Clarias nieuhofii* (SL 110 mm)

9d *Xenentodon canciloides* (SL 40 mm)

9e *Hemirhamphodon pogonognathus* (SL 37 mm)



9f *Monopterus albus* (SL 266 mm SL)

9g *Macrognathus aculeatus* (SL 107 mm)

9h *Macrognathus maculates* (SL 162 mm)

Plate 9

10a *Mastacembelus favus* (SL 175 mm)

10b *Parambassis apogonoides* (SL 67 mm)

10c *Parambassis siamensis* (SL 39 mm)

10d *Nandus nebulosus* (SL 30 mm)

10e *Pristolepis fasciata* (SL 63 mm)

10f *Oxyeleotris marmorata* (SL 180 mm)

10g *Anabas testudineus* (SL 69 mm)

10h *Helostoma temminkii* (SL 61 mm)

Plate 10

11a *Belontia hasselti* (SL 52 mm)

11b *Betta pugnax* (SL 46 mm)

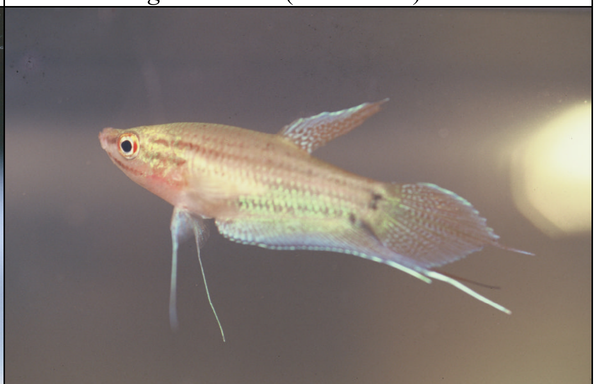
11c *Betta waseri* (SL 40 mm)

11d *Luciocephalus pulcher* (SL 107 mm)

11e *Sphaerichthys osphromenoides* (SL 32 mm)

11f *Trichogaster leerii* (SL 44 mm)

11g *Trichogaster trichopterus* (SL 35 mm)



11h *Trichopsis vittata* (SL 30 mm)

Plate 11

12a *Osphronemus goramy* (SL 93 mm)

12b *Channa lucius* (SL 195 mm)

12c *Channa melasoma* (SL 182 mm)

12d *Channa micropeltes* (SL 600 mm)

12e *Channa striata* (SL 25 mm)

12f *Achiroides leucorhynchos* (SL 29 mm)

12g *Monotrete palembangensis* (SL 150 mm)

Plate 12

CHAPTER 4

VERTICAL DISTRIBUTION PATTERN OF THE FISH COMMUNITY IN TASEK BERA

4.1 INTRODUCTION

The main objective of community ecology studies is to determine the factors responsible for patterns of species abundance and distributions (Hinch *et al.,* 1991). Hinch *et al.* used multivariate ordination techniques and concluded that biogeographic processes, physical environmental factors and predator processes have been very influential in shaping abundance and distributions of ubiquitous littoral zone fishes in Ontario. This present study deals only on diversity and vertical distribution of fishes in Tasek Bera. In order to describe the vertical distribution of fish, various environmental conditions and how the fish respond to the environment need to be considered. Although there has been many studies on vertical distribution of marine fishes and plankton (Potter & Lough, 1987, Fernö *et al*., 1995, Aglen *et al*., 1999, Sarojini & Sarma, 2001 and Onsrud, *et al*., 2004), as well as freshwater fishes (Bohl, 1980, Bollens & Frost, 1989, Helland *et al*., 2007, Prchalová, 2008, Warner, 2009); very few studies have been done locally. The only study on vertical distribution in Peninsular Malaysia was done by Zakaria-Ismail and Sabariah (1995) at Temenggor Dam, Hulu Perak, Malaysia. Based from the water quality parameters, they discovered that dissolved oxygen levels from the surface to a depth of 6 m was sufficient to support life. However, Malaysian lacustrine fishes can tolerate low oxygen as long as the water temperature remains reasonably low, for instance *Hampala macrolepidota* (Cyprinidae) was found present at the depth of 28 m despite the low DO levels (Zakaria-Ismail and Sabariah, 1995).

In the case of Tasek Bera, there is no information available on vertical distribution of fish and abundance correlated to chemical and physical environmental factors. Shiraishi *et al*. (1972) and Mizuno and Furtado (1982) focused only on diel activity and feeding habits of Tasek Bera fishes. In addition, no correlation analysis was done on distribution of fishes and their relationship to environmental factors. A study on vertical distribution of fishes will provide useful information on the spatial partitioning of sympatric species found in Tasek Bera.

Study by Piet and Guruge (1997) showed that feeding behaviour and vertical distribution differed significantly among species. For most species, feeding behaviour and vertical distribution changed throughout the 24-hour period and both processes were correlated. Water level changes, temperature and illumination, along with spawning migrations relevant for most species were among the main environmental factors influencing fish movement (Hohausovà *et al.,* 2003). Taylor (2000) found abundance and daytime vertical distribution of planktonic fish larvae in an oligotrophic South Island lake during the day appeared to be influenced mainly by light levels and water temperatures. Świerzowskia *et al.* (2000) used hydroacoustic methods in Solina reservoir in Poland to observe correlation between fish and zooplankton abundances, concluding that the vertical distribution of zooplankton and fish were affected by the thermocline. Maximal concentrations of both were observed in a well-illuminated surface layer with the highest temperature and oxygen concentration. Another research done by Mous (2004) by using hydroacoustics method showed that fish were more dispersed at night than during the day. He concluded that low water transparency over-ruled the light sensitivity of European smelt and caused them to stay higher in the water column. Bhat (2004) used canonical correspondence analysis (CCA) to confirm a strong correlation between species and environmental parameters (positively correlated to stream depth and width and negatively to altitude). Another CCA done by Akin (2005) indicated that salinity and turbidity were the most important environment parameters affecting fishes at the estuarine gradient.

The goals of this study were to describe the vertical distribution of fishes observed at different times, depths and places at Tasek Bera and conducting CCA statistical analyses to investigate its correlation to the environmental parameters.

4.2 MATERIALS AND METHODS

In order to study vertical distribution pattern of fishes in the 11 sampling sites (refer to Table 2.1 in Chapter 2), gill nets of three different mesh sizes (25.4 mm, 50.8 mm and 76.2 mm) were attached side by side and lowered until reaching the bottom of a particular site. The gill nets were deployed at 14:00 hours over a 24 hour period and inspected at eight hours intervals, when the nets were pulled up, specimens caught were recorded and identified on site. The intervals between 06:00 to 14:00 hours was categorised as early day sampling, from 14:00 to 22:00 hours as evening sampling and 22:00 hours to 06:00 hours as night sampling. The study on vertical distribution was conducted 3 times per site, on a monthly rotation between the 11 sites during the period from April 2004 to December 2005. The taxonomic classification used in this study follows Nelson (2006) and the species names follow after Lim and Tan (2001). The depth at which each specimen was caught was determined based on the position where it was trapped on the net. The specimens were brought back to the base camp and its fresh weight recorded. Only a representative sample for each species were kept as specimens and fixed in 10% formalin in the field. In the laboratory, the specimens were soaked in water for several days. They were later transferred to 70% alcohol for long term storage. The preserved specimens were deposited in the Museum of Zoology of the Science Faculty, University of Malaya with an acronym of UMKL.

Analysis using canonical correspondence analysis (CCA) was done to investigate association of fish vertical distribution to seven environmental variables which were TDS, TSS, turbidity, conductivity, dissolved oxygen and pH. These environmental variables have been discussed in detail in Chapter 2. In order to assess depth as a factor in the distribution of fish species, it was included as an environmental variable. In total, eight environmental variables were included in the CCA analysis. Both data of fish abundance and environmental variables were log-transformed (log (x+1)) except pH, before CCA was carried out to obtain a normal distribution (Ter Braak, 1986; Underwood, 1997; Kouamélan *et al*., 2003; Akin *et al*., 2005 and Okogwu *et al*., 2009). This multivariate analysis was conducted by using CANOCO version 4.5 (ter Braak and Šmilauer, 2002). Monte Carlo permutation analysis simulation with forward selection option within the CANOCO package were used to test the significance (p = 0.05) of each variable's contribution to each CCA axis. As a result, an ordination diagram with species and sites represented by points and environmental variables represented by arrows was formulated. This two-dimensional diagram shows the main pattern of diversion in community composition as influenced by the environmental variables, and the distribution of the species shows along each environmental variable. The position of the arrowhead for an environmental variable depends on the eigenvalues of the axes and the intraset correlations of that environmental variable to the axes. The arrow length of the environmental variables indicates the strength of their influence on the species distribution, thus the longer the arrows the stronger the influence on fish distribution. The size of the angles between the variable arrows indicates the association of the environmental variables with each other. Environmental variables with angles closer to 90^0 tend to vary independently of one another; less than that means strong positive association whereas closer to 180^0 indicate a strong negative correlation between those variables. The abundance or probability of occurrence of a particular species decreases with distance from its location in the diagram.

4.3 RESULTS

4.3.1 FISH SPECIES COMPOSITION DISTRIBUTION BASED ON VERTICAL GILL NETTING

A total of 455 individuals of fish represented by 28 species from nine families were caught from the vertical gill samplings at 11 sites in Tasek Bera. Majority of the fish caught were Cyprinidae represented by 14 species, Siluridae with four species, Bagridae and Chandidae with two species each and Mastacembelidae, Nandidae, Helostomatidae and Osphronemidae with only one species respectively (Table 4.1). The most common and abundant species was *Labiobarbus festivus,* locally known as *ikan kawan*, comprising of about 26.6% of the total individuals caught, followed by *Cyclocheilichthys apogon* (*ikan kemperas*) with 15.4%, both are members of the family Cyprinidae (Fig. 4.1). Other species only contributed about 8.8% to 0.2% of the overall composition. *Osteocheilus hasseltii, Oxygaster anomalura, Hampala macrolepidota* and *Notopterus notopterus* were also a substantial component of the community in Tasek Bera with 8.8%, 7.9%, 6.2% and 5.5% respectively. Low abundance was recorded for *Chitala lopis*, *Helostoma temminkii*, *Mastacembelus favus*, *Osphronemus goramy* and *Parambassis apogonoides* with only one individual of each species caught by the vertical gill net throughout the sampling period.

Table 4.1 shows that *Labiobarbus festivus* and *Hampala macrolepidota* were caught at all sampling sites. *Chitala lopis, Osteocheilus melanopleurus* and *Helostoma temminkii* were only caught at Lubuk Salleh. *Parachela oxygastroides*, *Mastacembelus favus*, *Osphronemus goramy* were only caught at Lubuk Benal. *Labiobarbus leptocheilus* and *Wallago leerii* were caught at Lubuk Ranting Patah and Lubuk Kuin (opposite the Perhilitan's jetty) respectively.

Table 4.1. Occurrence of fish species at 11 sampling sites in Tasek Bera. The symbol "✓" indicates the presence of the species. Fishes were caught by using vertical gill nets with different mesh sizes (25.4 mm, 50.8 mm and 76.2 mm). The gills net were set for 24 hours. Collections of samples were done at 0600, 1400 and 2200 hours. Kuin (1) stands for Lubuk Kuin (beside the Perhilitan's jetty) and Kuin (2) stands for Lubuk Kuin (opposite the Perhilitan's jetty).

Family	**Species**	**Kuin (1)**	**Kuin (2)**	**Sanglar**	**Tg Bahau**	**Penarikan**	**LSalleh**	**Gedubang**	**Keminyan**	**R. Patah**	**Chenderong**	**Benal**
Notopteridae	*Chitala lopis*						✓					
	Notopterus notopterus	✓	✓		✓	✓		✓	✓			
Cyprinidae	*Barbonymus schwanenfeldii*	✓	✓			✓	✓	✓	✓	✓		✓
	Crossocheilus oblongos					✓		✓				
	Cyclocheilichthys apogon	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
	Cyclocheilichthys heteronema	✓		✓		✓			✓			
	Hampala macrolepidota	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Labiobarbus festivus	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Labiobarbus leptocheilus									✓		
	Luciosoma trinema	✓	✓	✓					✓			✓
	Osteocheilus hasseltii			✓	✓	✓	✓	✓	✓	✓	✓	
	Osteocheilus melanopleurus						✓					
	Osteocheilus waandersii									✓	✓	
	Oxygaster anomalura		✓	✓	✓	✓	✓		✓		✓	✓
	Parachela oxygastroides											✓
	Thynnichthys thynnoides	✓	✓					✓	✓	✓		
Bagridae	*Hemibagrus bleekeri*					✓		✓				
	Mystus nigriceps			✓								✓
Siluridae	*Kryptopterus limpok*			✓	✓		✓		✓	✓		
	Kryptopterus apogon		✓	✓	✓	✓	✓		✓	✓		✓
	Ompok hypopthalmus	✓		✓	✓		✓		✓			
	Wallago leerii		✓									
Mastacembelidae	*Mastacembelus favus*											✓
Chandidae (Ambassidae)	*Parambassis apogonoides*						✓					✓
	Parambassis siamensis			✓			✓					
Nandidae	*Pristolepis fasciata*	✓		✓	✓		✓	✓				
Helostomatidae	*Helostoma temminkii*						✓					
Osphronemidae	*Osphronemus goramy*											✓
	Total species	10	10	13	10	11	15	9	13	10	6	12

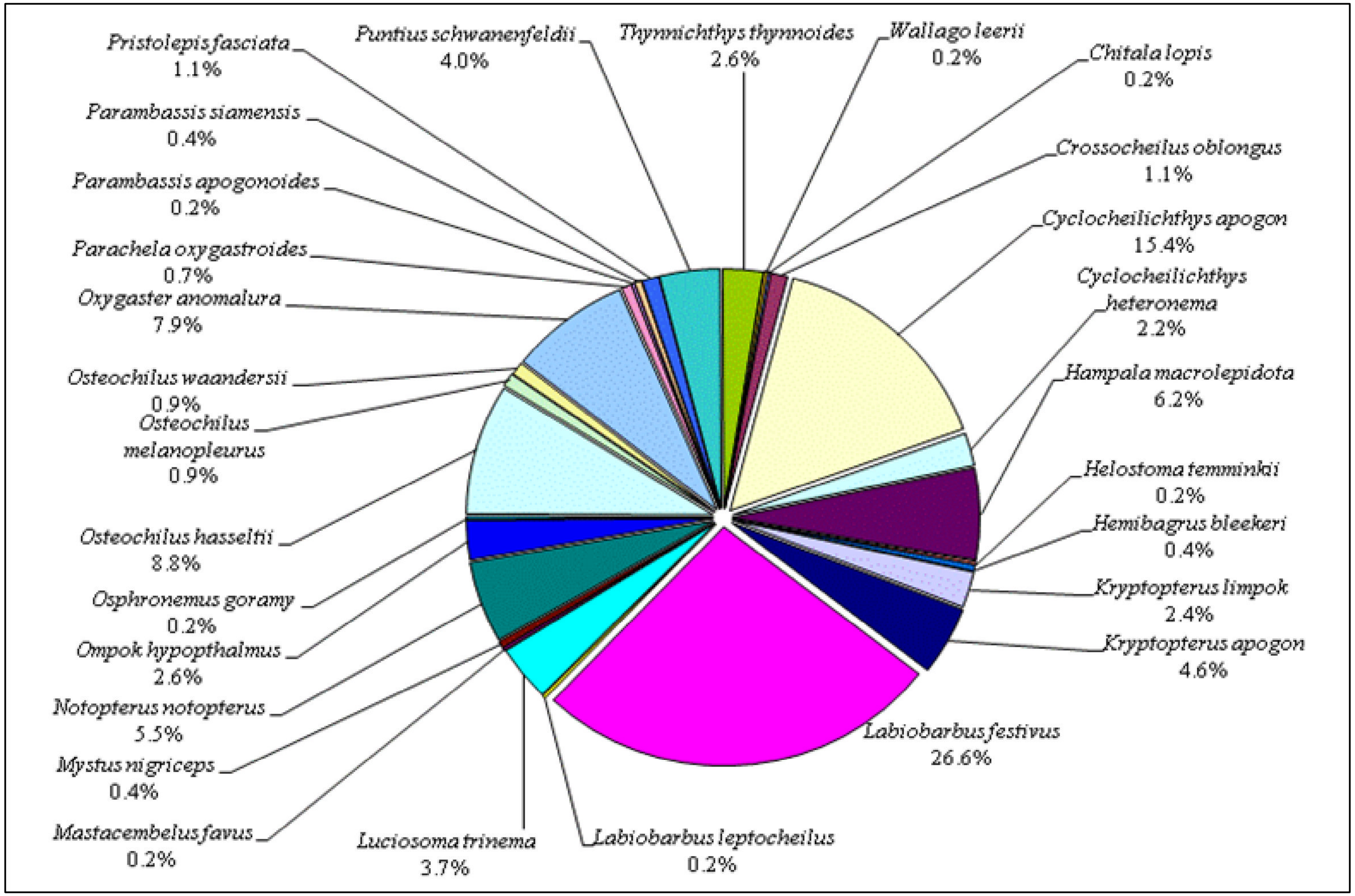
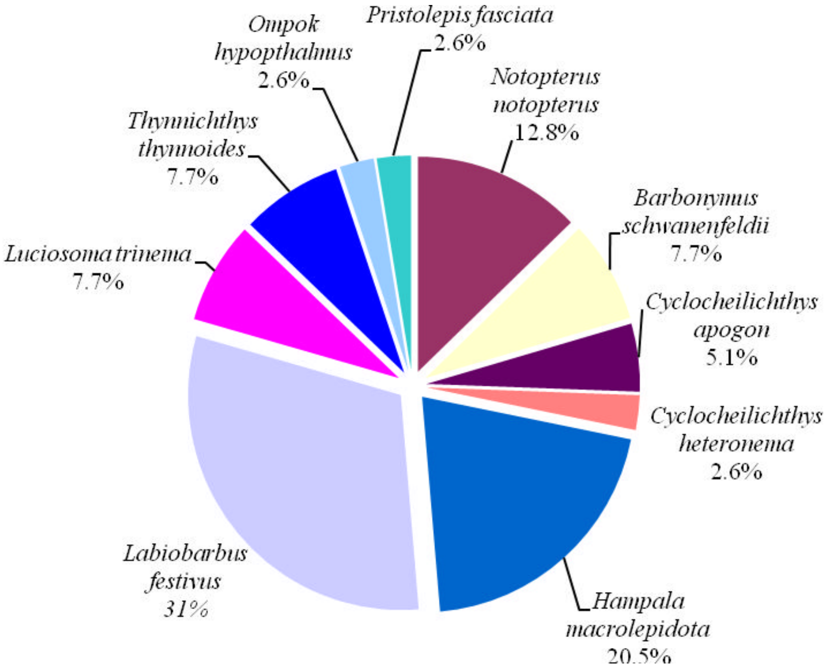


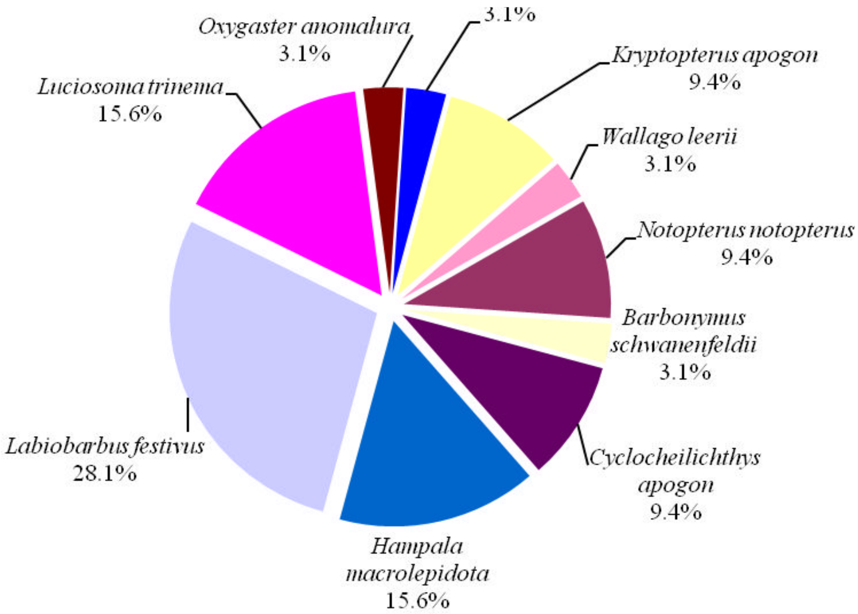
Figure 4.1. Species composition of fishes based on the number of individuals caught using vertical gill nets at Tasek Bera.

Figures 4.2(a-k) show that *L. festivus* contributed the highest proportion in the fish caught at all sampling sites of Tasek Bera except at Tanjung Bahau, Lubuk Salleh, Lubuk Chenderong and Lubuk Benal. Lubuk Salleh, Lubuk Chenderong and Lubuk Benal were dominated by *C. apogon* with 24.9%, 60% and 18.3% of the total fishes caught respectively (Fig. 4.2f,j & k). *Oxygaster anomalura* (26.7%) was the most abundant species sampled at Tanjung Bahau (Fig.4.2d).

Lubuk Salleh had the highest fish biomass sampled by vertical gill net, followed by Teluk Keminyan (Table 4.2). Tanjung Penarikan and Lubuk Chenderong showed the lowest biomass contributing about 7.3% of the total biomass sampled. *Labiobarbus festivus* contributed the highest biomass at all sampling sites of Tasek Bera except in Tanjung Bahau, Lubuk Salleh and Lubuk Chenderong (Fig. 4.3a-k). In Lubuk Benal, it contributed the highest biomass although it was the third most abundant species. The total biomass of *L. festivus* of 1253 g at Teluk Keminyan contributed almost 20% of all individuals caught from Tasek Bera. The biomass of *Thynnichthys thynnoides* from Teluk Gedubang contributed almost 50% of the total biomass of this species caught at Tasek Bera (Table 4.2).



a) Lubuk Kuin located beside Perhilitan's jetty



b) Lubuk Kuin located opposite Perhilitan's Jetty

Figure 4.2a-b. Species composition of fishes based on the number of individuals caught using vertical gill nets at Lubuk Kuin beside and opposite Perhilitan's jetty, Tasek Bera.

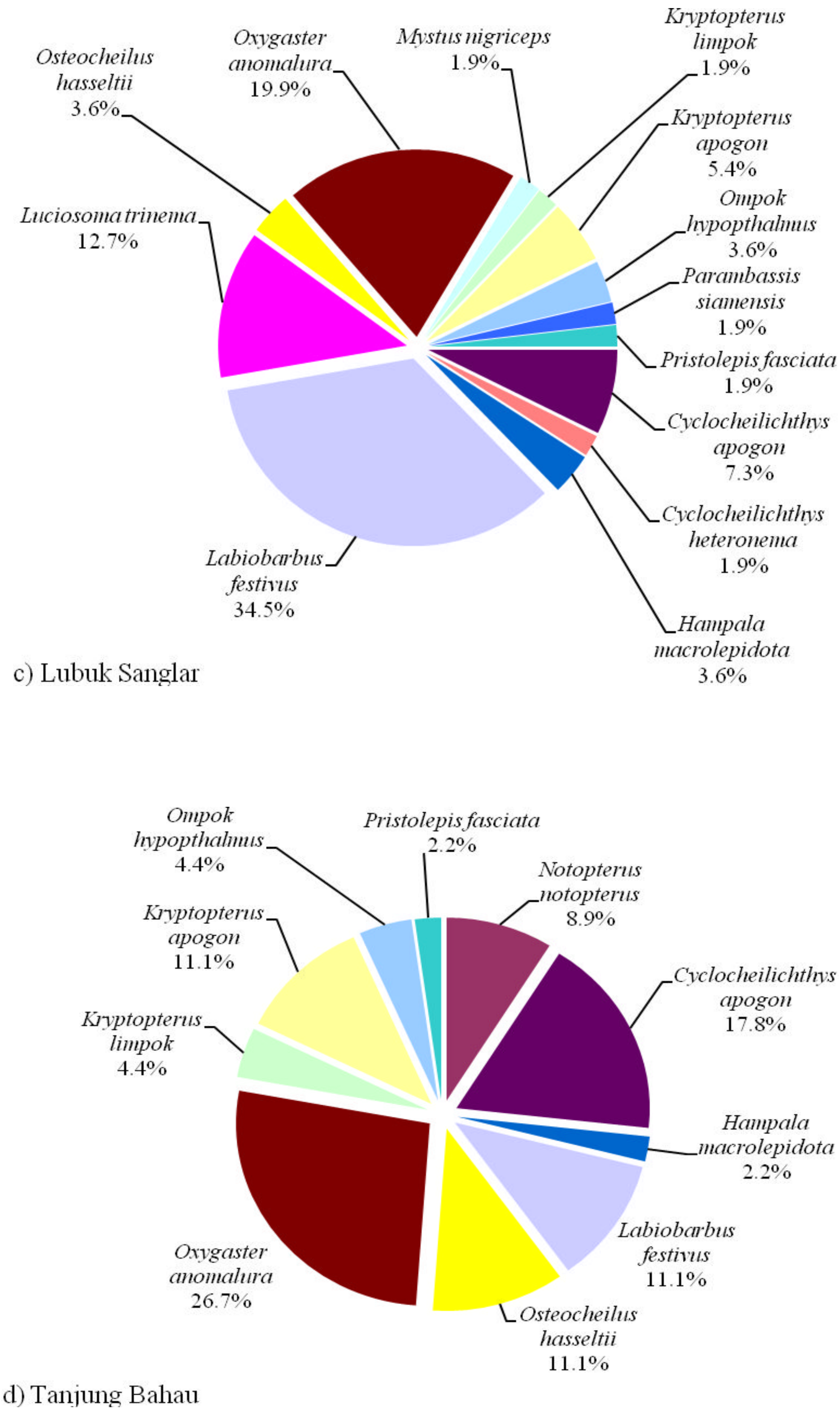
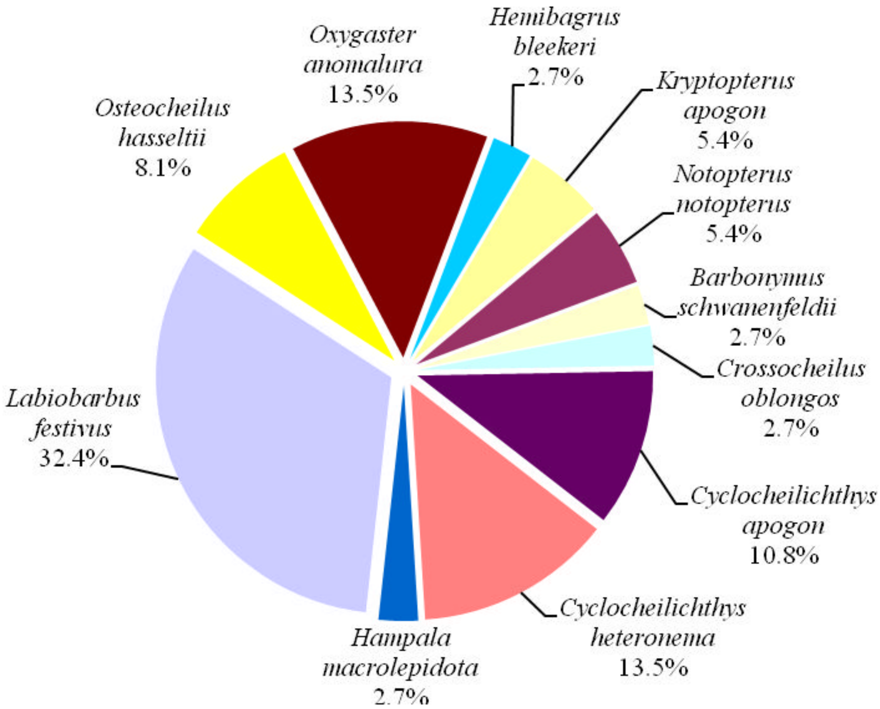
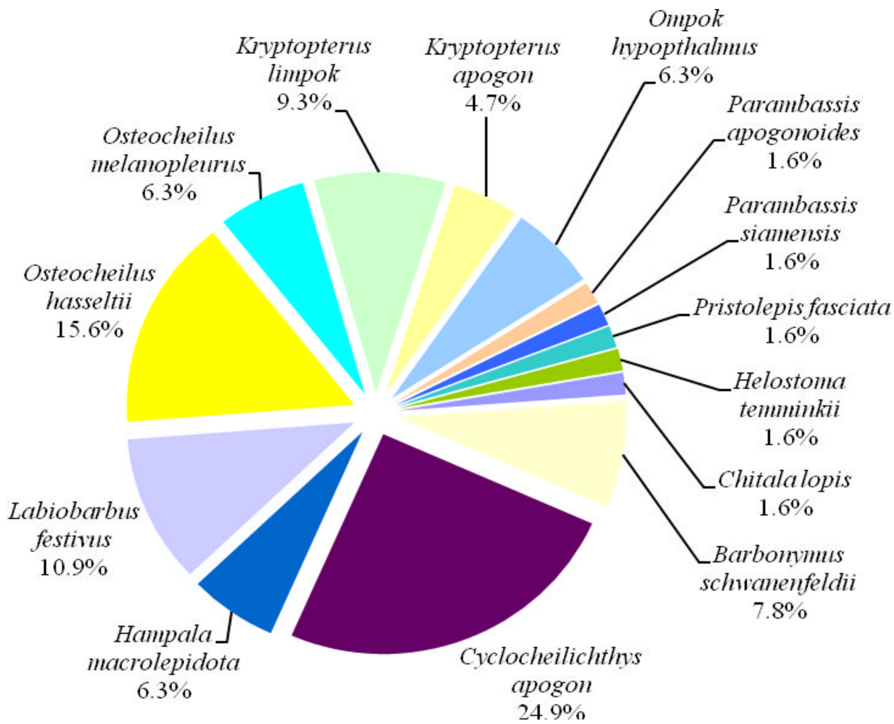


Figure 4.2c-d. Species composition of fishes based on the number of individuals caught using vertical gill nets at Lubuk Sanglar and Tanjung Bahau, Tasek Bera.

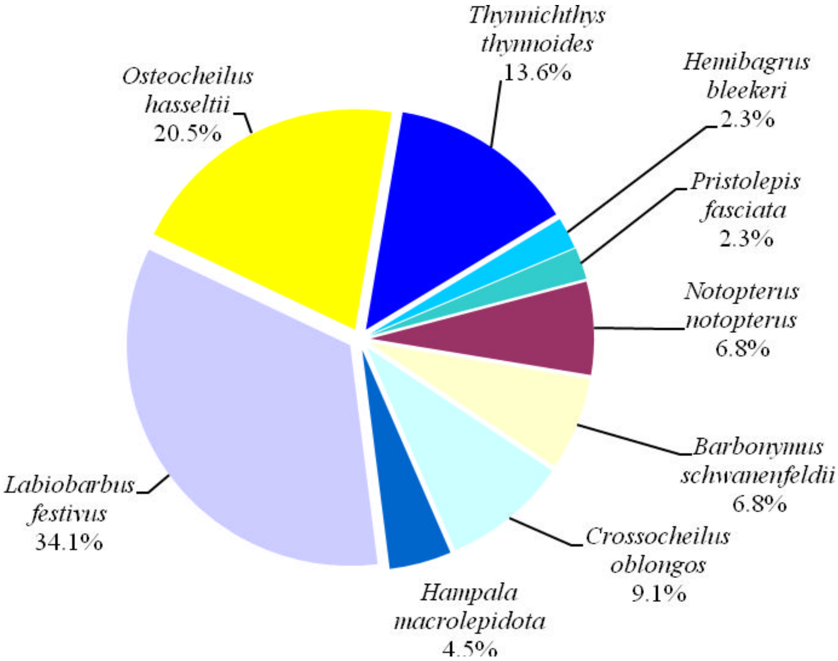


e) Tanjung Penarikan

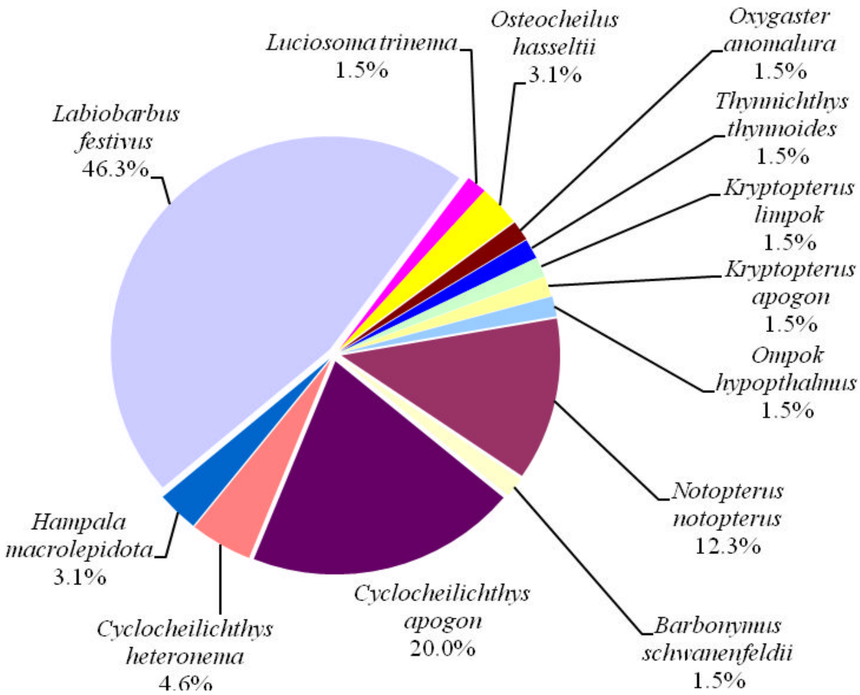


f) Lubuk Salleh

Figure 4.2e-f. Species composition of fishes based on the number of individuals caught using vertical gill nets at Tanjung Penarikan and Lubuk Salleh, Tasek Bera.

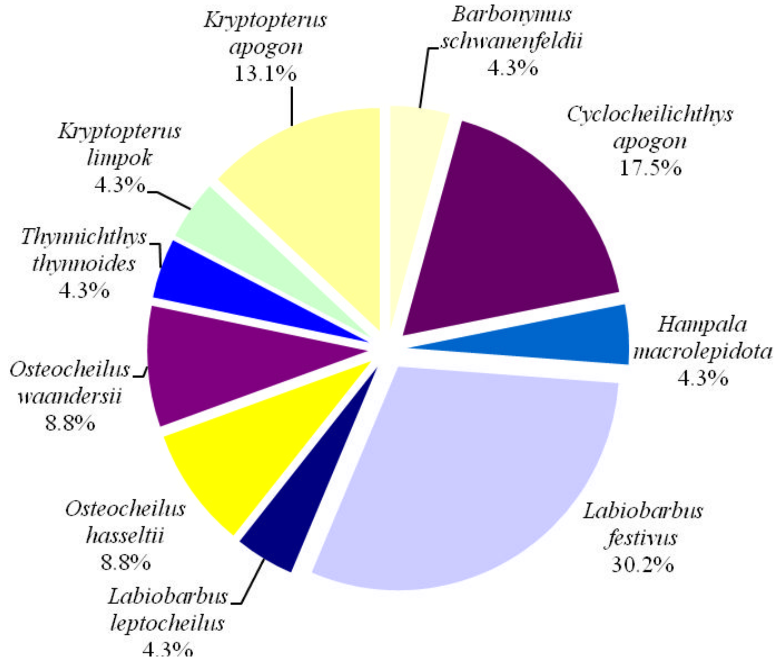


g) Gedubang

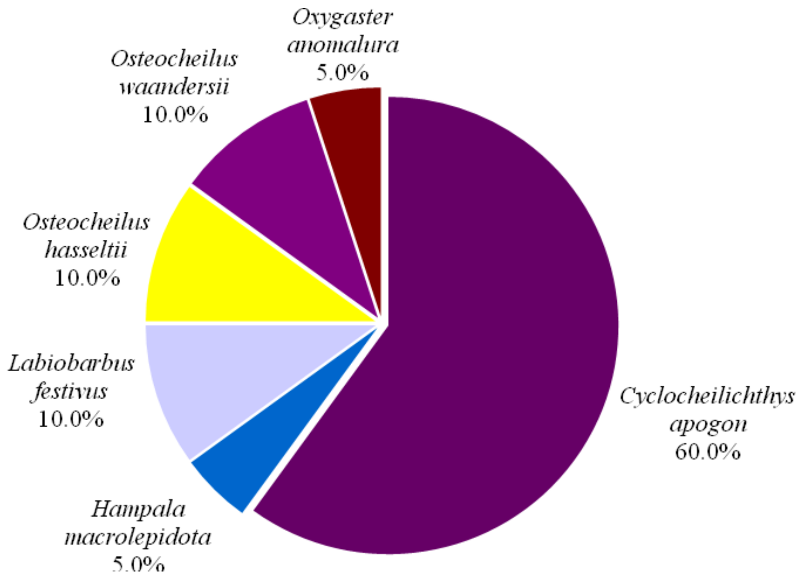


h) Keminyan

Figure 4.2g-h. Species Species composition of fishes based on the number of individuals caught using vertical gill nets at Gedubang and Keminyan, Tasek Bera.

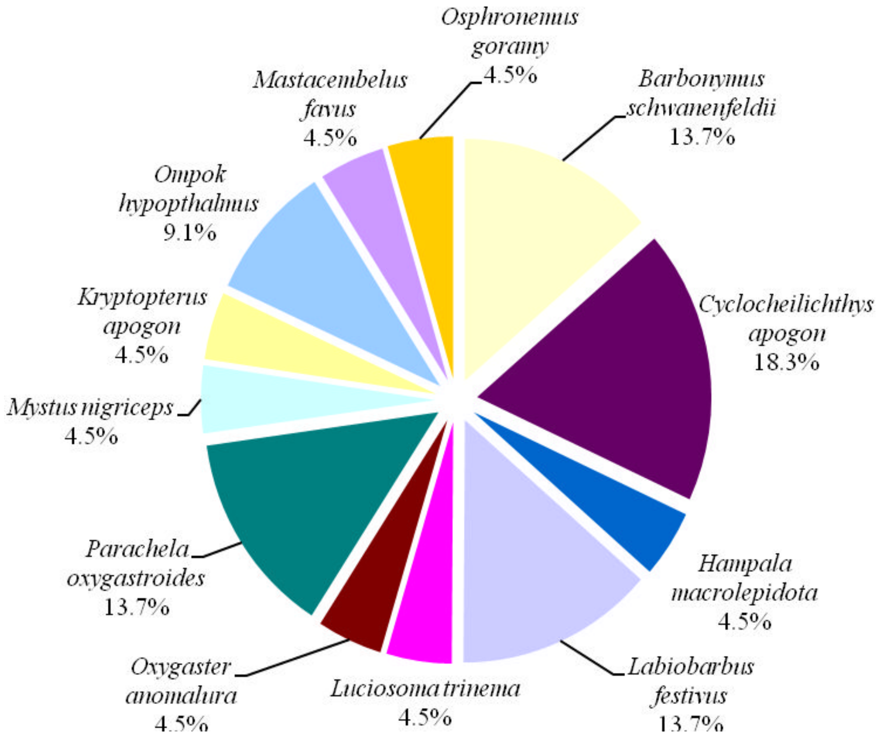


i) Ranting Patah



j) Chenderong

Figure 4.2i-j. Species composition of fishes based on the number of individuals caught using vertical gill nets Ranting Patah and Chenderong, Tasek Bera.



k) Benal

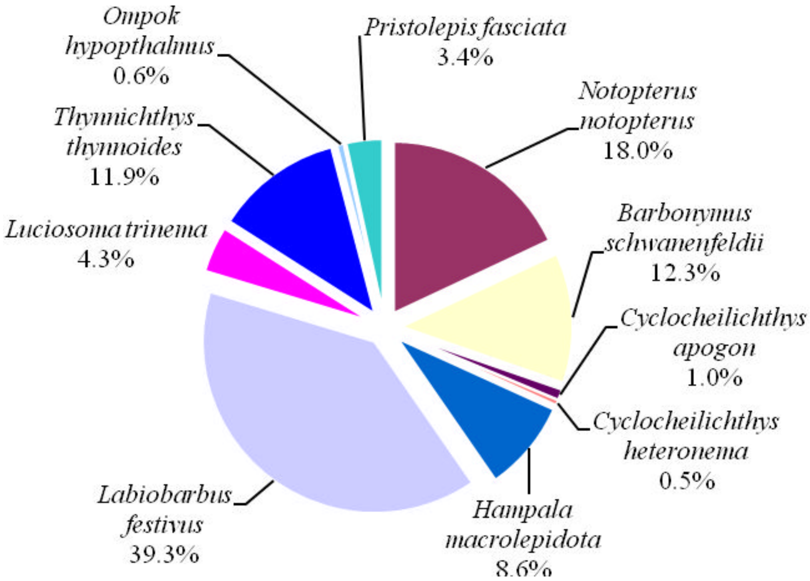
Figure 4.2k. Species composition of fishes based on the number of individuals caught using vertical gill nets at Lubuk Benal, Tasek Bera.

Table 4.2. Biomass (g) of fish species at 11 sampling sites in Tasek Bera. Fishes were caught using vertical gill nets with different mesh sizes (25.4mm, 50.8 mm and 76.2 mm). The gills nets were set for 24 hours. Collection of samples were done at 0600, 1400 and 2200 hours. Kuin (1) stands for Lubuk Kuin (beside the Perhilitan's jetty) and Kuin (2) stands for Lubuk Kuin (opposite the Perhilitan's jetty).

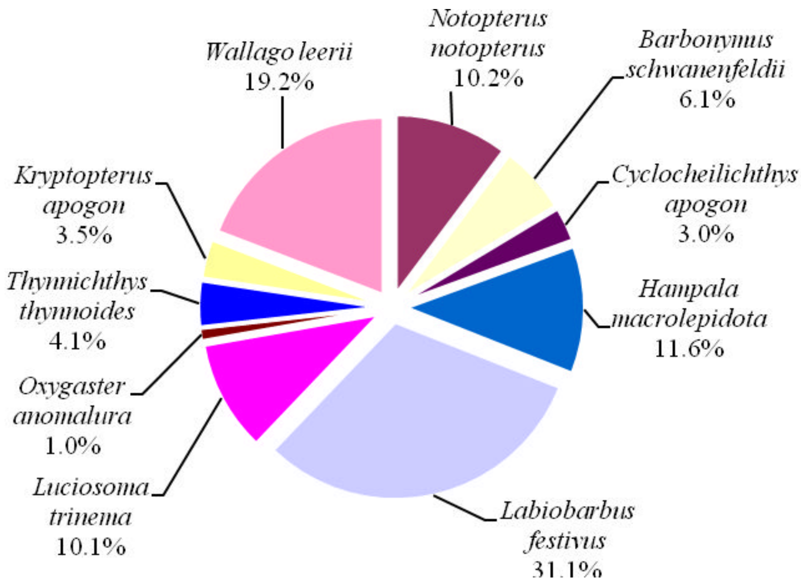
Family	**Species**	**Kuin (1)**	**Kuin (2)**	**Sanglar**	**Tg Bahau**	**Penarikan**	**Salleh**	**Gedubang**	**Keminyan**	**Ranting Patah**	**Chenderong**	**Benal**	**Total (g)**
Notopteridae	*Chitala lopis*						319						319
	Notopterus notopterus	448	210		268	109		136	580				1751
Cyprinidae	*Barbonymus schwanenfeldii*	305	126			12	260	48	91	26		284	1152
	Crossocheilus oblongos					22		68					90
	Cyclocheilichthys apogon	25	62	57	111	73	324		229	64	248	70	1263
	Cyclocheilichthys heteronema	12		16		65			48				141
	Hampala macrolepidota	213	237	106	26	19	596	223	53	39	80	159	1751
	Labiobarbus festivus	977	638	879	111	372	168	857	1253	428	148	338	6169
	Labiobarbus leptocheilus									17			17
	Luciosoma trinema	108	207	245					35			68	663
	Osteocheilus hasseltii			122	92	44	232	216	38	32	86		862
	Osteocheilus melanopleurus						322						322
	Osteocheilus waandersii									45	41		86
	Oxygaster anomalura		21	165	207	81	73		14		19	25	605
	Parachela oxygastroides											53	53
	Thynnichthys thynnoides	296	84					666	127	172			1345
Bagridae	*Hemibagrus bleekeri*					23		181					204
	Mystus nigriceps			26								24	50
Siluridae	*Kryptopterus limpok*			30	124		379		48	17			598
	Kryptopterus apogon		71	55	134	39	88		21	269		58	735
	Ompok hypopthalmus	16		49	41		260		19			32	417
	Wallago leerii		393										393

Table 4.2
(Continued)

Family	Species	Kuin (1)	Kuin (2)	Sanglar	Tg. Bahau	Penarikan	Salleh	Gedubang	Keminyan	Ranting Patah	Chenderong	Benal	Total (g)
Mastacembelidae	*Mastacembelus favus*											83	83
Chandidae (Ambassidae)	*Parambassis apogonoides*						9						9
	Parambassis siamensis			9			9						18
Nandidae	*Pristolepis fasciata*	85		136	226		7	152					606
Helostomatidae	*Helostoma temminkii*						125						125
Osphronemidae	*Osphronemus goramy*											330	330
	Total biomass (g)	2485	2049	1895	1340	859	3171	2547	2556	1109	622	1524	20157

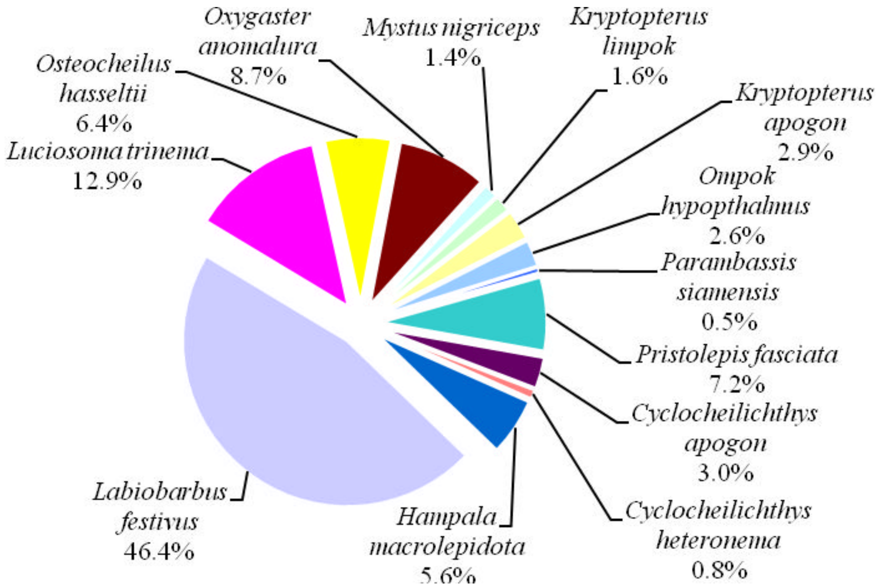


a) Lubuk Kuin (beside Perhilitan's jetty)

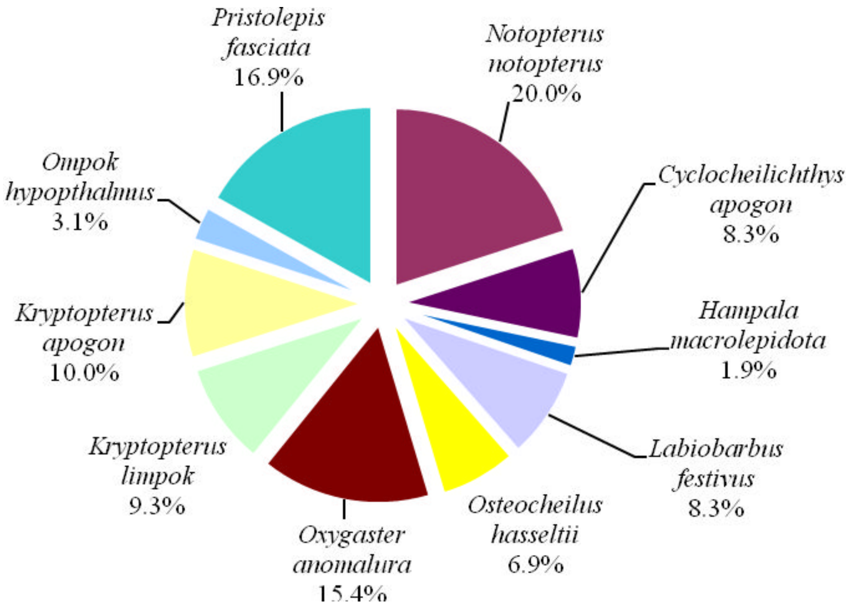


b) Lubuk Kuin (opposite Perhilitan's jetty)

Figure 4.3a-b. Species composition based on the biomass of fishes caught using vertical gill nets at Lubuk Kuin (beside Perhilitan's jetty) and Lubuk Kuin (opposite Perhilitan's jetty), Tasek Bera.

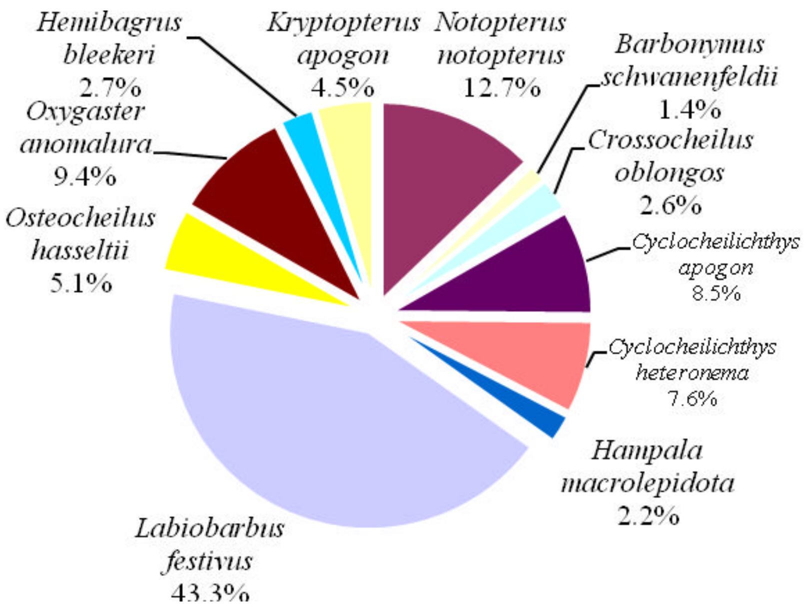


c) Lubuk Sanglar

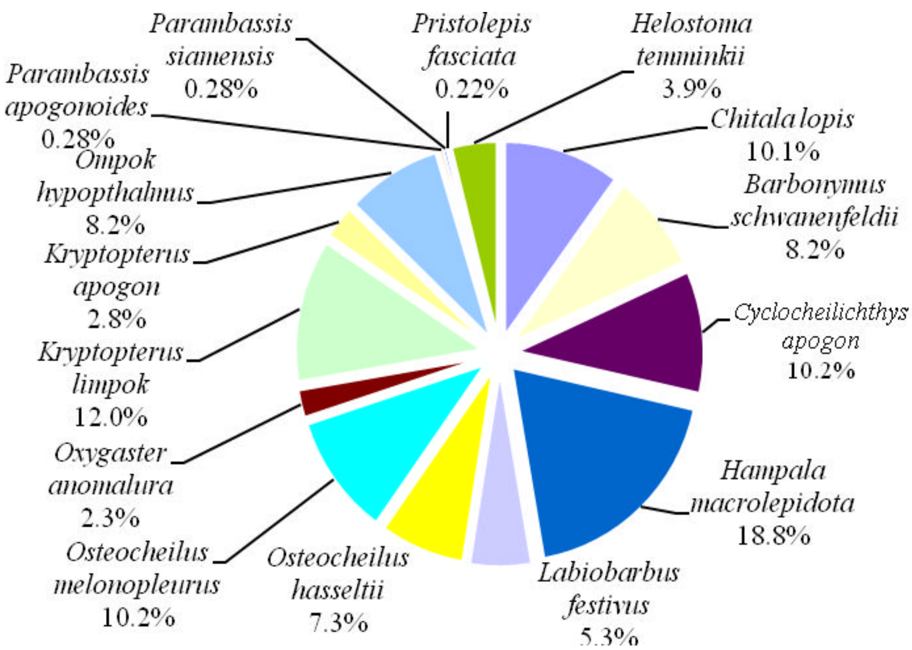


d) Tanjung Bahau

Figure 4.3c-d. Species composition based on the biomass of fishes caught using vertical gill nets at Lubuk Sanglar and Tanjung Bahau, Tasek Bera.

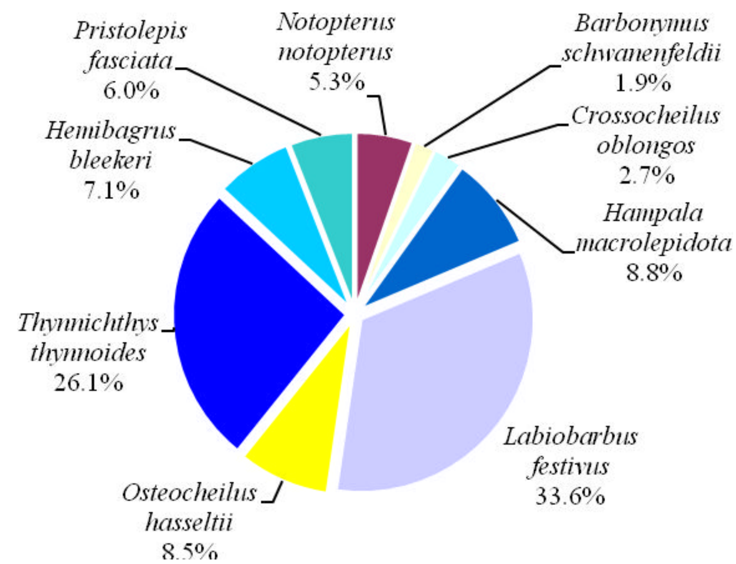


e) Tanjung Penarikan

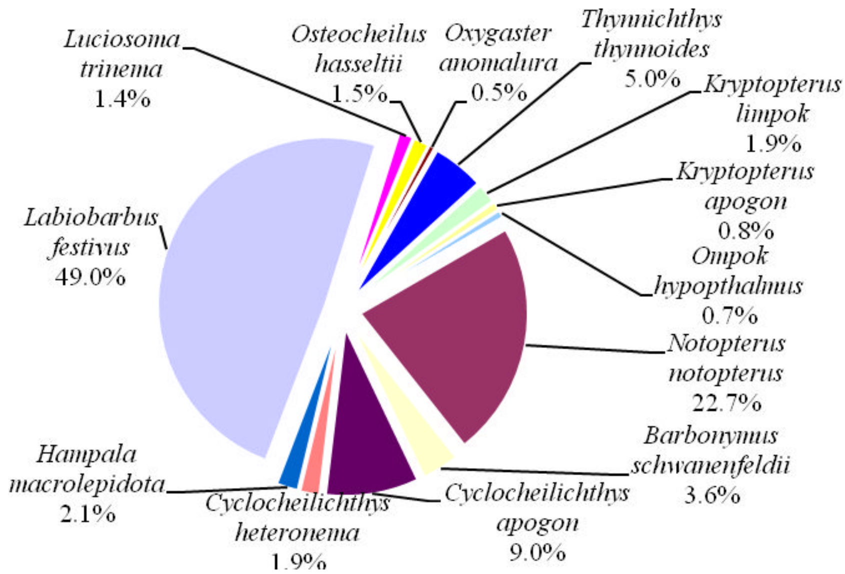


f) Lubuk Salleh

Figure 4.3e-f. Species composition based on the biomass of fishes caught using vertical gill nets at Tanjung Penarikan and Lubuk Salleh, Tasek Bera.

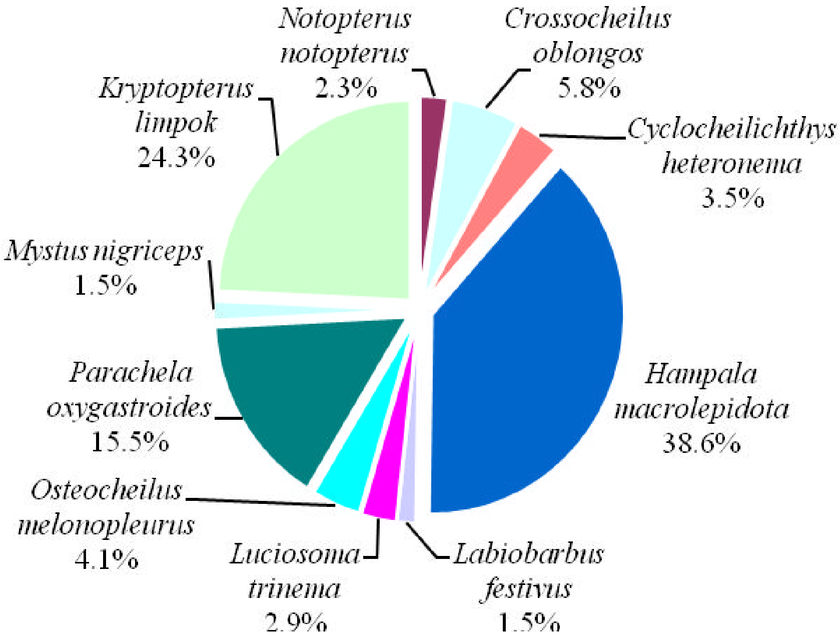


g) Teluk Gedubang

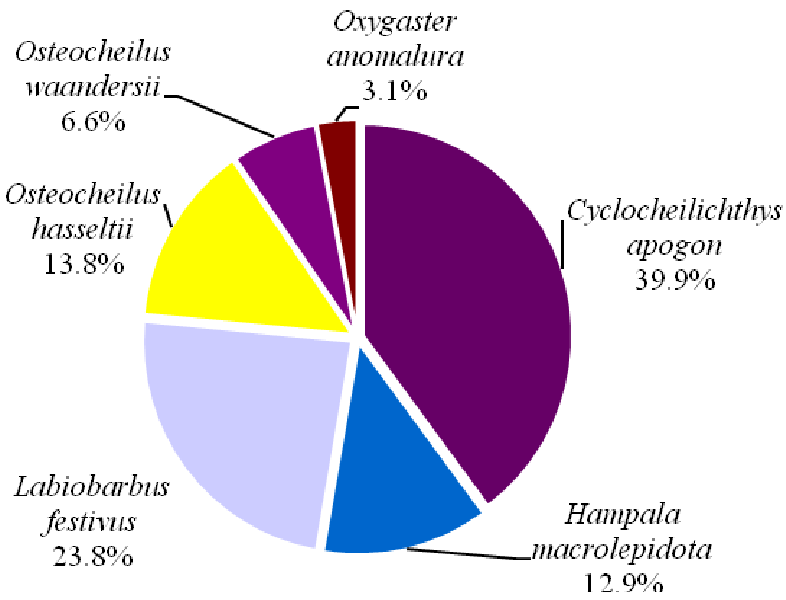


h) Teluk Keminyan

Figure 4.3g-h. Species composition based on the biomass of fishes caught using vertical gill nets at Teluk Gedubang and Teluk Keminyan, Tasek Bera.

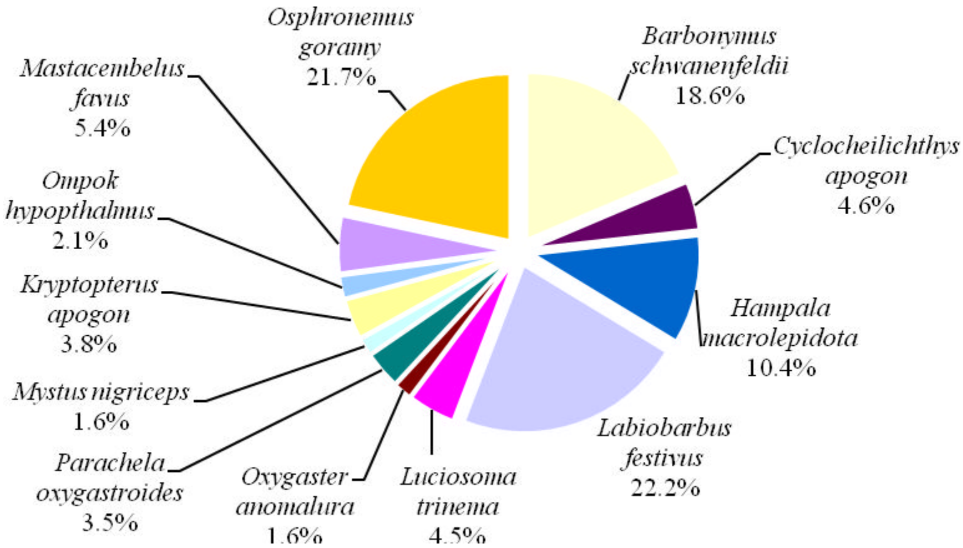


i) Lubuk Ranting Patah



j) Lubuk Chenderong

Figure 4.3i-j. Species composition based on the biomass of fishes caught using vertical gill nets at Lubuk Ranting Patah and Lubuk Chenderong, Tasek Bera.



k) Lubuk Benal

Figure 4.3k. Species composition based on the biomass of fishes caught using vertical gill nets at Lubuk Benal, Tasek Bera.

Lubuk Salleh has the highest Shannon-Weiner Diversity Index, indicating that this site had the highest diversity of fish and number of individuals caught as compared to other sites in Tasek Bera (Table 4.3). A total of 15 species from six families were caught here. This site also showed the highest biomass with *Hampala macrolepidota* being the biggest contributor and followed by *Kryptopterus limpok* (Fig. 4.3f). According to individual numbers caught at this site, *Cyclocheilichthys apogon* showed the highest abundance of species followed by *Osteochilus hasseltii*.

Lubuk Chenderong with the lowest Shannon-Weiner Diversity Index only showed six species with total of 20 individuals and all of them are common cyprinids in Tasek Bera. The 40% of the total biomass for this site was contributed by *Cyclocheilichthys apogon* (Fig. 4.3j).

In terms of species similarity, Teluk Keminyan had a rather similar species composition as to Lubuk Kuin at two stations which were located beside and opposite of Perhilitan's Jetty, as well as Tanjung Penarikan and Lubuk Ranting Patah as shown by the high value of Sϕrensen similarity index (Table 4.4). Lubuk Sanglar was similar to Tanjung Bahau as both sites are situated close together. Both sites also had similar species composition to Lubuk Salleh, which has the highest species diversity. Lubuk Chenderong shared less common species to Lubuk Kuin station located beside Perhilitan's jetty and Teluk Gedubang as it is situated further up from the main open waters of Lubuk Kuin. Teluk Gedubang showed the lowest index value same as Lubuk Benal as it isolated from other sampling sites.

Table 4.3. The number of species, number of individuals, biomass (g) and Shannon-Weiner Diversity Index (H') for the eleven study sites in Tasek Bera. Fishes were caught by using vertical gill nets with different mesh sizes (25.4 mm, 50.8 mm and 76.2 mm). The gill nets were set for 24 hours. Collection of samples was done at 0600, 1400 and 2200 hours.

No.	**Site Sampling**	**Species no.**	**Individuals no.**	**Biomass (g)**	**Shannon-Weiner Index (H')**	**Maximum Diversity (H' max)**	**Evenness J**
1	Lubuk Kuin (beside Perhilitan's jetty)	10	39	2485	1.98	2.30	0.86
2	Lubuk Kuin (opposite Perhilitan's jetty)	10	32	2049	2.04	2.30	0.89
3	Lubuk Sanglar	13	60	1895	2.07	2.56	0.81
4	Tanjung Bahau	10	45	1340	2.05	2.30	0.89
5	Tanjung Penarikan	11	37	859	2.06	2.40	0.86
6	Lubuk Salleh	15	68	3171	2.38	2.71	0.88
7	Teluk Gedubang	9	44	2547	1.86	2.20	0.85
8	Teluk Keminyan	13	65	2556	1.74	2.56	0.68
9	Lubuk Ranting Patah	10	23	1109	2.04	2.30	0.89
10	Lubuk Chenderong	6	20	622	1.30	1.79	0.73
11	Lubuk Benal	12	22	1524	2.33	2.48	0.94
	Total		**455**	**20157**			
	Mean	**10.82**	**41.36**	**1832.45**	**1.99**	**2.35**	**0.84**
	S.D.	**2.40**	**17.08**	**810.94**	**0.29**	**0.24**	**0.08**

Table 4.4. Similarity in species composition between two sites based on Sϕrensen similarity index, ranging from a value of 0 where there is no species overlap between the sites, to a value of 1 when exactly the same species are found in both sites. Kuin (1) refers to Lubuk Kuin (beside the Perhilitan's jetty) and Kuin (2) refers to Lubuk Kuin (opposite the Perhilitan's jetty).

	Kuin (1)	Kuin (2)	Sanglar	Tg. Bahau	Penarikan	L. Salleh	Gedubang	Keminyan	Rtg. Patah	Chenderong
Kuin (1)										
Kuin (2)	0.70									
Sanglar	0.61	0.52								
Tg Bahau	0.60	0.60	0.78							
Penarikan	0.57	0.67	0.58	0.67						
L Salleh	0.48	0.48	0.71	0.72	0.54					
Gedubang	0.63	0.53	0.36	0.53	0.70	0.42				
Keminyan	0.78	0.78	0.62	0.62	0.75	0.64	0.55			
Rtg. Patah	0.50	0.60	0.52	0.60	0.57	0.56	0.53	0.70		
Chenderong	0.38	0.50	0.53	0.63	0.59	0.48	0.40	0.53	0.63	
Benal	0.55	0.64	0.64	0.55	0.52	0.52	0.29	0.64	0.45	0.44

Figure 4.4 shows cluster analysis of Tasek Bera sampling sites according to occurrence of species and their abundance. Both Lubuk Kuin stations, beside and opposite of Perhilitan's jetty are similar and closely related is Tanjung Penarikan. The existence of *Labiobarbus festivus, Cyclocheilicthys apogon, Hampala macrolepidota* and *Luciosoma trinema* are the main contributor for the similarity between them. Another one obvious cluster composed of Lubuk Ranting Patah, Lubuk Benal and Lubuk Chenderong. *Notopterus notopterus* was not caught at those sites making them a bit different from the first cluster. The occurrence of *Barbonymus schwanenfeldii* at Lubuk Ranting Patah and Lubuk Benal caused the two sites to be clustered together. Lubuk Keminyan is the most different sites as compared to the other sites because it has the highest number of individuals caught and second highest in term of species diversity.

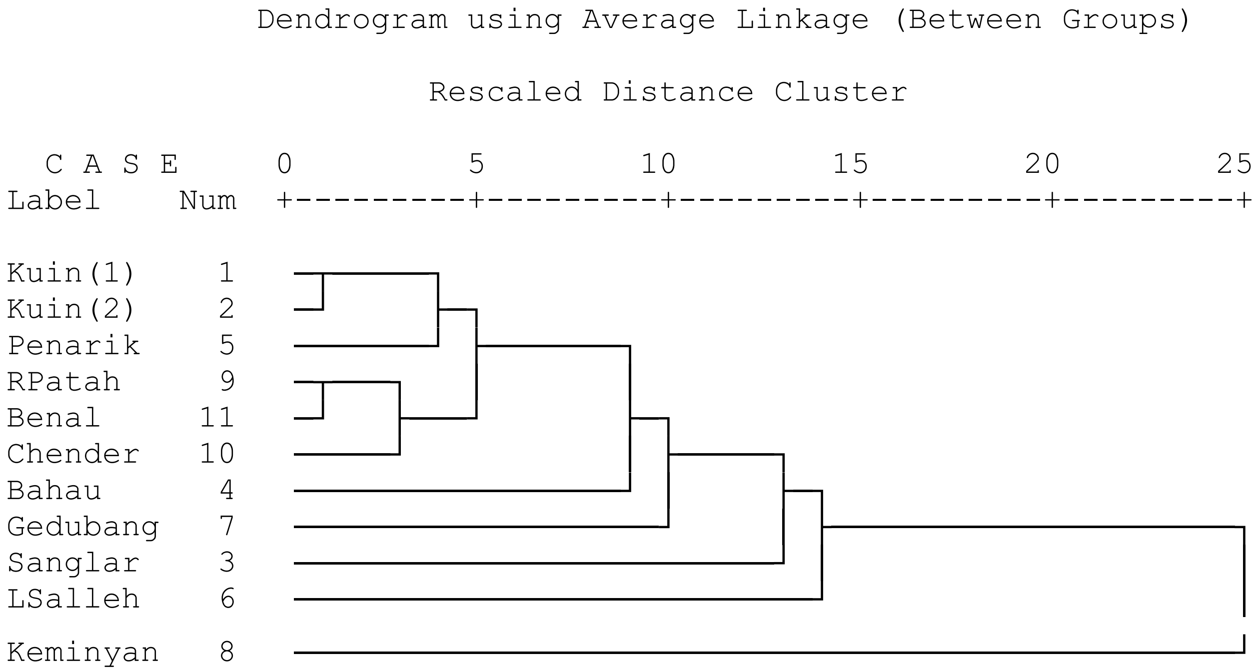


Figure 4.4 Cluster analysis of Tasek Bera sampling sites according to occurrence of species and abundance.

4.3.2 Vertical distribution

4.3.2.1 Composition

Barbonymus schwanenfeldii, Cyclocheilichthys apogon, Hampala macrolepidota, *Labiobarbus festivus* and *Kryptopterus apogon* occurred at almost every depth layers. At the deepest area which was 6 to 7 m deep, only two individuals of *C. apogon* and *K. limpok* were caught (Table 4.5). Shannon-Weiner Diversity Index showed that at depth 0 to 1 m had the highest heterogeneity followed by depth 2 to 3 m and depth 1 to 2 m, although the number of species and individuals recorded at the depth 1 to 2 m was the highest (Table 4.6). The high value of the index not only indicates the species richness but also suggests that populations of the species present in the areas are evenly distributed. Pielou's Index (J) (Table 4.6) showed small variation in communities in Tasek Bera for each respective depth.

Figure 4.5 showed that Cyprinidae was the most abundant fish family captured at every depth level and the highest abundance was at level 1 to 2 m from the surface (33.7%). The highest number of *L. festivus* was captured at depth of 1 to 2 m (64 individuals) comprising of about 53% of the total individual number of this species. Family Siluridae also existed at every level except at the depth 5 to 6 m from the surface, but contributed less than 3.7% of the fish abundance. Over 88% of all individual regardless of species were captured within 3 m of the surface (Fig. 4.6).

Table 4.5 Occurrence of fish species according to depth of the 11 sampling sites in Tasek Bera. Values in brackets are the total number of individuals caught at the particular depth. Fishes were caught by using vertical gill net with different mesh sizes (25.4 mm, 50.8 mm and 76.2 mm). The gill net was set for 24 hours. Collections of samples were done at 06:00, 14:00 and 22:00 hours.

		Depth (m)						
Family	**Species**	**0 to 1**	**1 to 2**	**2 to 3**	**3 to 4**	**4 to 5**	**5 to 6**	**6 to 7**
Notopteridae	*Chitala lopis*						1	
	Notopterus notopterus	8	16	1				
Cyprinidae	*Crossocheilus oblongos*		2	2	1			
	Cyclocheilichthys apogon	9	34	15		1	9	2
	Cyclocheilichthys heteronema		6	4				
	Hampala macrolepidota	2	16	5	2	2	1	
	Labiobarbus festivus	11	64	31	11	4		
	Labiobarbus leptocheilus				1			
	Luciosoma trinema	16	1					
	Osteocheilus hasseltii	10	15	13			3	
	Osteocheilus melanopleurus		1		1	1	1	
	Osteocheilus waandersii	2	1		1			
	Oxygaster anomalura	25	10		1			
	Parachela oxygastroides	2	1					
	Barbonymus schwanenfeldii	8	1	5	3	1		
	Thynnichthys thynnoides	3	2	7				
Bagridae	*Hemibagrus bleekeri*			2				
	Mystus nigriceps		1	1				
Siluridae	*Kryptopterus limpok*		4	2		1	2	2
	Kryptopterus apogon	11	3	3	3		1	
	Ompok hypopthalmus	6	2	3			1	
	Wallago leerii			1				
Mastacembelidae	*Mastacembelus favus*	1						
Chandidae (Ambassidae)	*Parambassis apogonoides*	1						
	Parambassis siamensis		1	1				
Nandidae	*Pristolepis fasciata*	1	3	1				
Helostomatidae	*Helostoma temminkii*			1				
Osphronemidae	*Osphronemus goramy*		1					

Table 4.6 Shannon-Weiner Index for each depth of the eleven sampling sites.

Depth (m)	Total species	Total individual no.	Shannon-Weiner Index (H')	Maximum Diversity (H' max)	Pielou's Index (J)
0 to 1	16	116	2.410	2.773	0.869
1 to 2	21	185	2.164	3.045	0.711
2 to 3	18	98	2.274	2.890	0.787
3 to 4	9	24	1.747	2.197	0.795
4 to 5	6	10	1.609	1.792	0.898
5 to 6	8	18	1.638	2.079	0.788
6 to 7	2	4	0.693	0.693	1.000

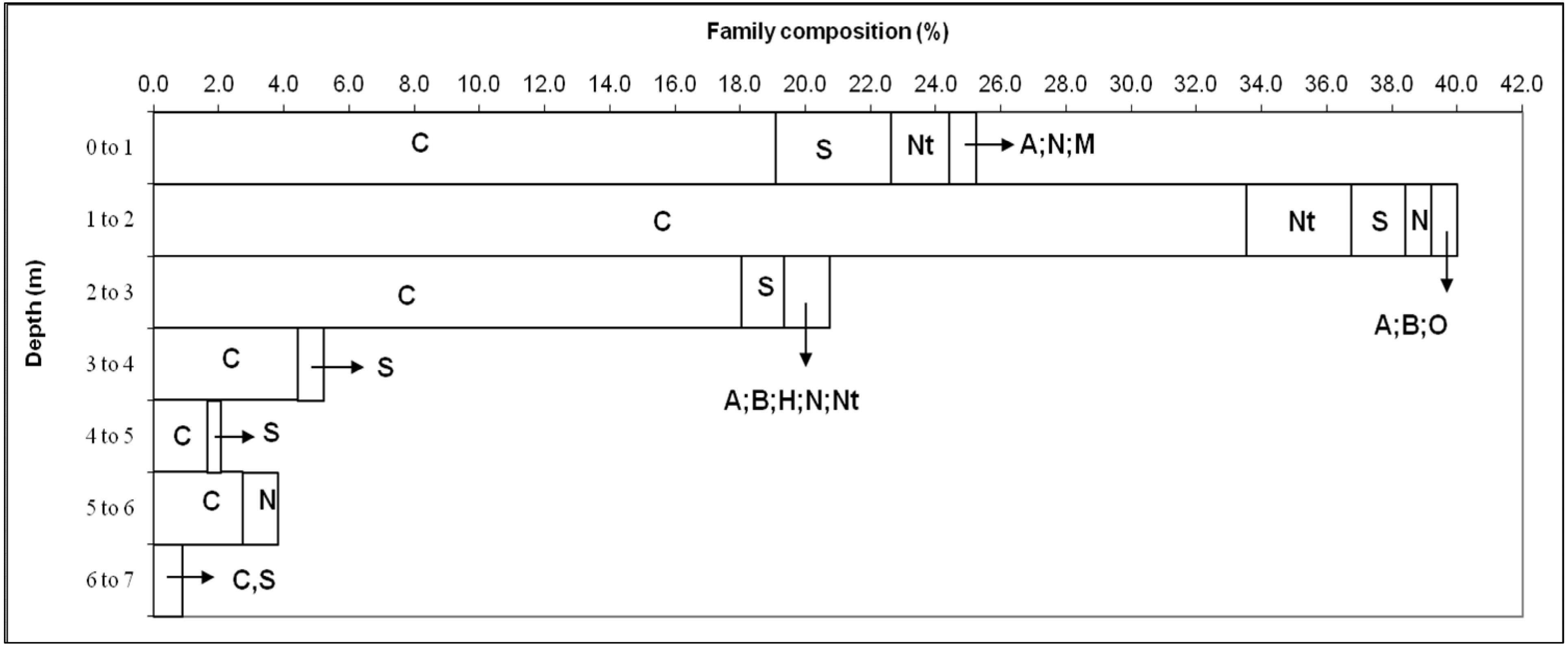


Figure 4.5 Percentage composition of fishes according to families at each level for Tasek Bera. Percentage was calculated of total individual caught for all the 11 sampling sites using gill net. (A = Ambassidae; B = Bagridae; C = Cyprinidae; H = Helostomatidae; M = Mastacembelidae; N = Nandidae; O = Osphronemidae; Nt = Notopteridae)

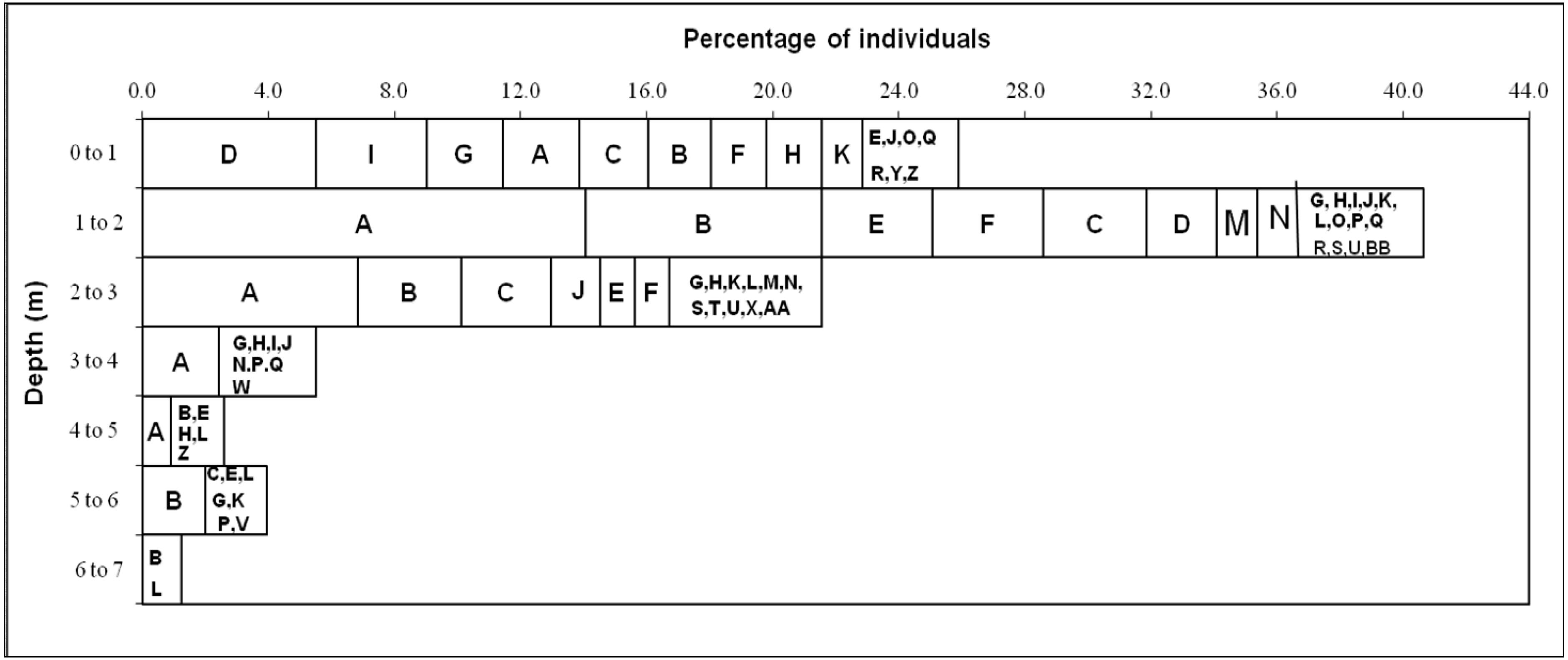


Figure 4.6 Percentage of individual number for each species caught at different depths from the surface. Fishes were caught by using a gill net. The last bars at each level are the compilation of species with percentage of occurance less than 1.0%. (A = *Labiobarbus festivus*; B = *Cyclocheilicthys apogon;* C = *Osteocheilus hasseltii;* D = *Oxygaster anumalura;* E = *Hampala macrolepidota;* F = *Notopterus notopterus;* G = *Kryptopterus apogon;* H = *Barbonymus schwanenfeldii;* I = *Luciosoma trinema;* J = *Thynnichthys thynnoides;* K = *Ompok hypopthalmus;* L = *Kryptopterus limpok;* M = *Cyclocheilichthys heteronema;* N = *Crossocheilus oblongos;* O = *Pristolepis fasciata;* P = *Osteocheilus melanopluerus;* Q = *Osteochilus waandersii;* R = *Parachela oxygastroides;* S = *Mystus nigriceps;* T = *Hemibagrus bleekeri;* U = *Parambassis siamensis;* V = *Chitala lopis;* W = *Labiobarbus leptocheilus;* X = *Wallago lerii;* Y = *Mastacembelus favus;* Z = *Parambassis apogonoides;* AA = *Helostoma temminkii;* BB = *Osphronemus goramy)*

4.3.2.2 Diel variation in vertical distribution

Total catch per unit effort (CPUE) was much higher during evening and night compared to early day (Fig. 4.7). The CPUE for those hours were about 4 times higher and contributed more than 80% of the total CPUE. The CPUE of the most abundant species (*Barbonymus schwanenfeldii, Cyclocheilichthys apogon, Hampala macrolepidota*, *Kryptopterus apogon, Labiobarbus festivus, Notopterus notopterus, Osteocheilus hasseltii* and *Oxygaster anumalora*) also showed the same pattern of distribution to sampling times (Table 4.7) with higher catches during evening and night sampling.

During night time *B. schwanenfeldii* occupied every layer of water of between 0 to 4m depth (Fig. 4.8 and 4.9a). None was caught during early day sampling and the highest mean vertical distribution was during evening time at the surface area.

The majority of *Cyclocheilicthys apogon* was caught in the 0 to 3 m depth layer during evening and night time but also caught in deeper waters (5 to 6 m). However, they were only caught at the 1 to 2 m depth layer in lower numbers during daytime sampling. *Hampala macrolepidota* were captured at almost every depth layer throughout the entire period of samplings. For both species, the highest mean vertical distribution was at 1 to 2 m depth layer during the evening sampling period (Fig. 4.9b and 4.9c).

Kryptopterus apogon was vertically distributed during evening and night time, mostly at the surface but was also caught in low numbers during the night sampling at 5 to 6 m depth. During the night sampling (22:00 – 06:00), the maximum mean vertical distribution occurred at 0-1 m depth (Fig. 4.9d). During evening sampling, the mean vertical distribution of this species between the layers where they were found showed almost the same value which was about 0.4 g. However, during the early day sampling, none were caught.

Labiobarbus festivus was the most abundant species with wide variation vertical distribution throughout the 24 hours and sampling result show that majority of them were found in the 1 to 2 m depth layer (Fig. 4.8). However difference in mean abundance between the 3 periods of vertical distribution sampling of this species was statistically significant ($\chi^2 = 26.0$, d.f. = 8, $P < 0.01$). This was the only species being captured in large numbers during day time and also distributed in deeper waters (4 to 5 m). Mean vertical distribution indicates that the maximum catch was at 1 to 2 m depth layer during evening sampling time (Fig. 4.9e).

Notopterus notopterus was sampled in the upper layers (0 to 3 m depth) during evening and night time only. At both periods, more than 50% of the total catch of this species were netted in the 1 to 2 m depth layer but the maximum vertical distribution was during night time at 1 to 2 m depth (Fig. 4.8 and 4.9f). No individual was caught during day time sampling.

The majority of *Osteochilus hasseltii* were found in the 0 to 3 m depth layer throughout the 24 hours of sampling. The highest mean vertical distribution was during evening time at level 1 to 2 m from the surface (Fig. 4.9g).

Vertical distribution pattern of *Oxygaster anomalura* showed that they preferred to swim in the surface water layer especially at night and evening period (Fig. 4.8 and 4.9h). They were also caught at 3 to 4 m depth during evening sampling. None were caught during the day.

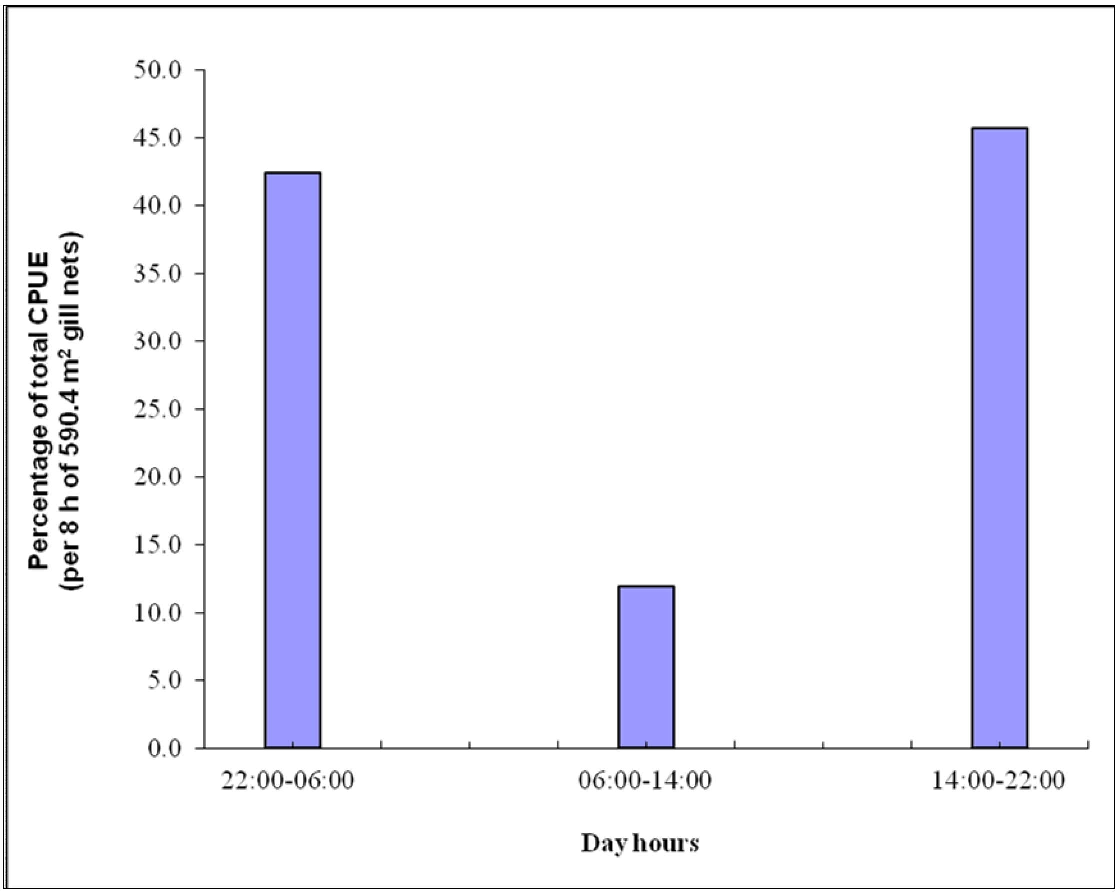


Figure 4.7 Percentage of total CPUE at Tasek Bera lake. Between 2200 to 0600 hours translate as "night", 0600 to 1400 hours as "early day" and 1400 to 2200 hours as "evening" time.

Table 4.7 Catch per unit effort (CPUE; biomass (g) per 8 h per 10,000 m^2 of gillnets) and percentage catch composition for dominant species at 06:00, 14:00 and 22:00.

	CPUE			% Catch composition		
	22:00-06:00	06:00-14:00	14:00-22:00	22:00-06:00	06:00-14:00	14:00-22:00
Barbonymus schwanenfeldii	9095.5	0.0	10416.7	9.8	0.0	9.0
Cyclocheilicthys apogon	11026.4	237.1	10128.7	11.9	0.7	8.8
Hampala macrolepidota	4488.5	9264.9	15904.5	4.8	27.5	13.8
Kryptopterus apogon	4911.9	0.0	7537.3	5.3	0.0	6.5
Labiobarbus festivus	30335.4	23882.1	50271.0	32.7	71.0	43.5
Notopterus notopterus	20274.4	0.0	9383.5	21.8	0.0	8.1
Osteocheilus hasseltii	7029.1	271.0	7300.1	7.6	23.5	6.3
Oxygaster anomalura	5657.2	0.0	4590.1	6.1	0.0	4.0
Total (g)	92818.4	33655.1	115531.8			

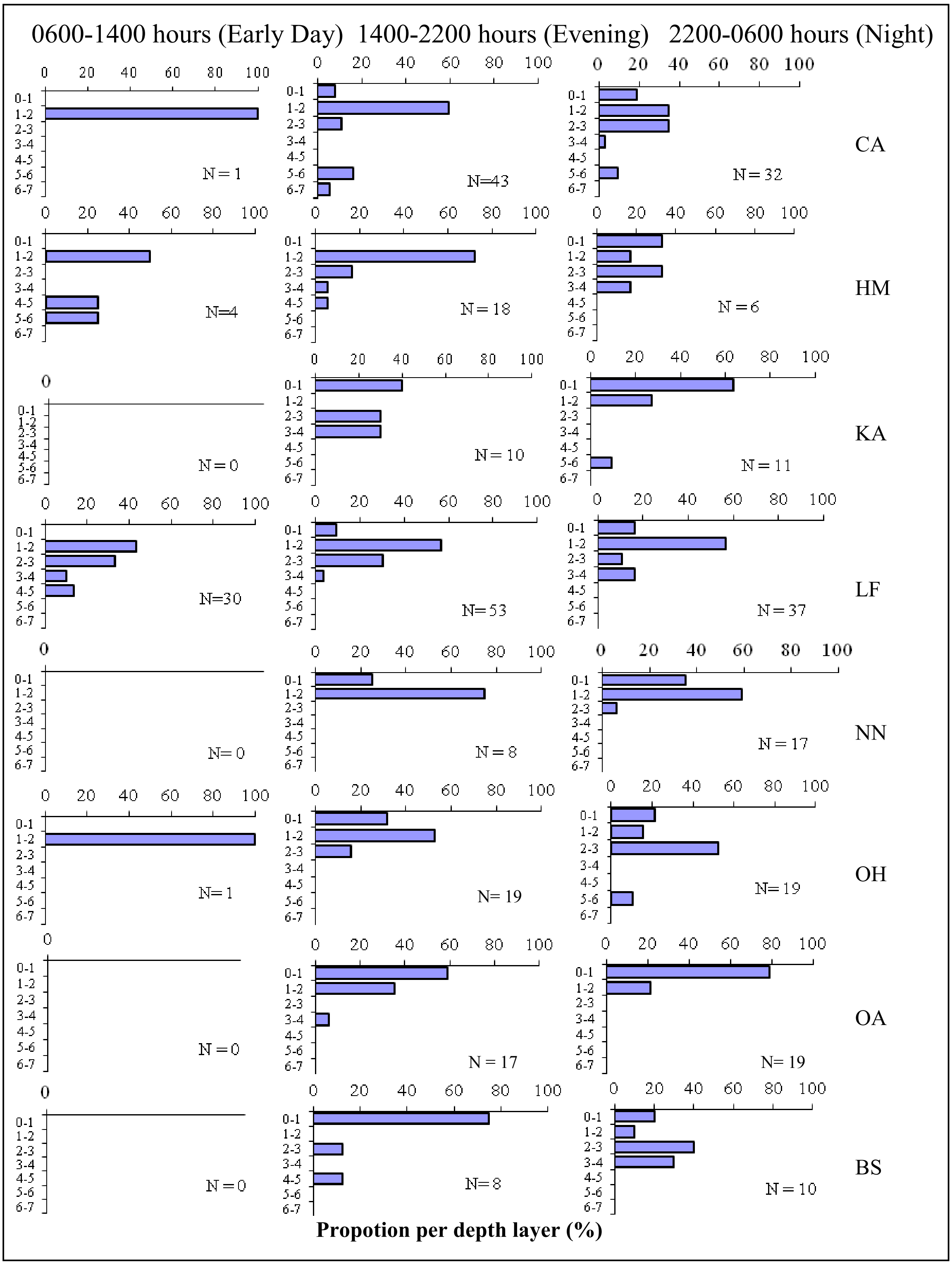


Figure 4.8. Vertical distribution of gill net catches for the eight most abundant fish species at 11 sampling site Tasek Bera lake. Percentage calculated as the proportion of the number of individual at the particular depth layer per total number of individual for that particular time. (CA = *Cyclocheilichthys apogon*; HM = *Hampala macrolepidota*; KA = *Kryptopterus apogon*; LF = *Labiobarbus festivus*; NN = *Notopterus notopterus*; OH = *Osteochilus hasseltii*; OA = *Oxygater anomalura* and BS = *Barbonymus schwanenfeldii)*

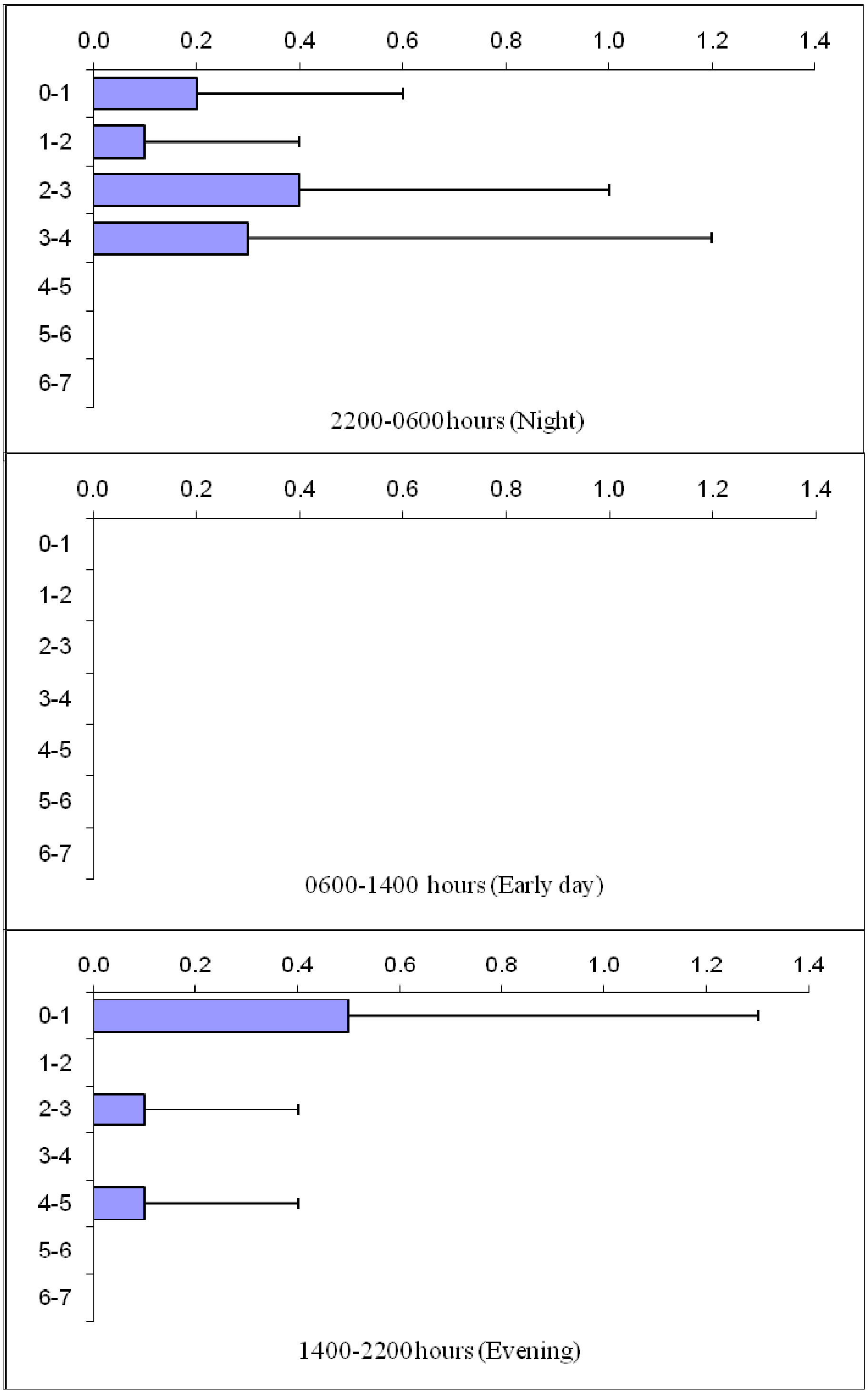


Figure 4.9(a) Mean vertical distribution of gillnet catches (ind./m^2) for *Barbonymus schwanenfeldii* calculated from 11 sampling sites of Tasek Bera. Error bars indicate the standard deviation.

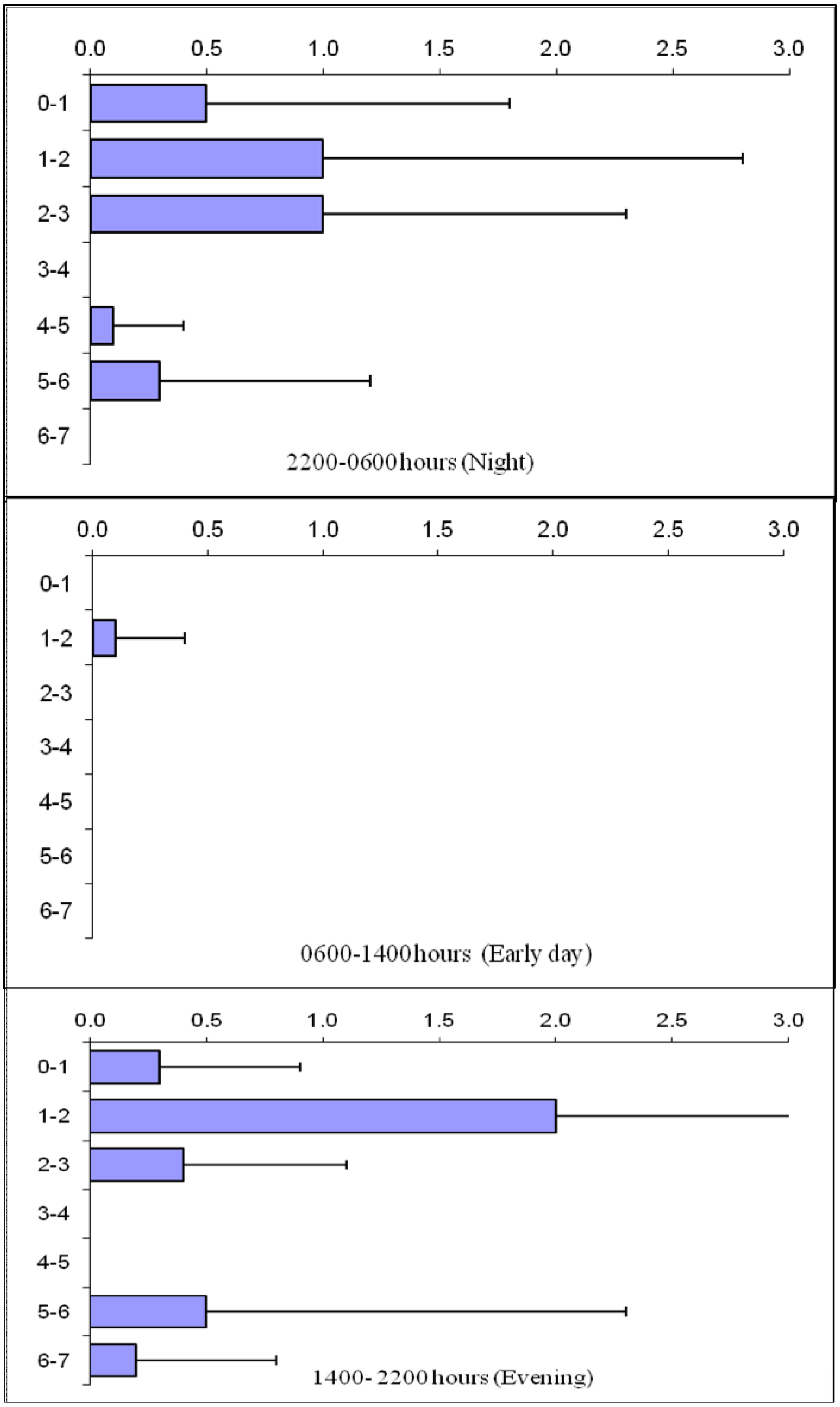


Figure 4.9(b) Mean vertical distribution of gillnet catches (ind./m^2) for *Cyclocheilicthys apogon* calculated from 11 sampling sites of Tasek Bera. Error bars indicate the standard deviation.

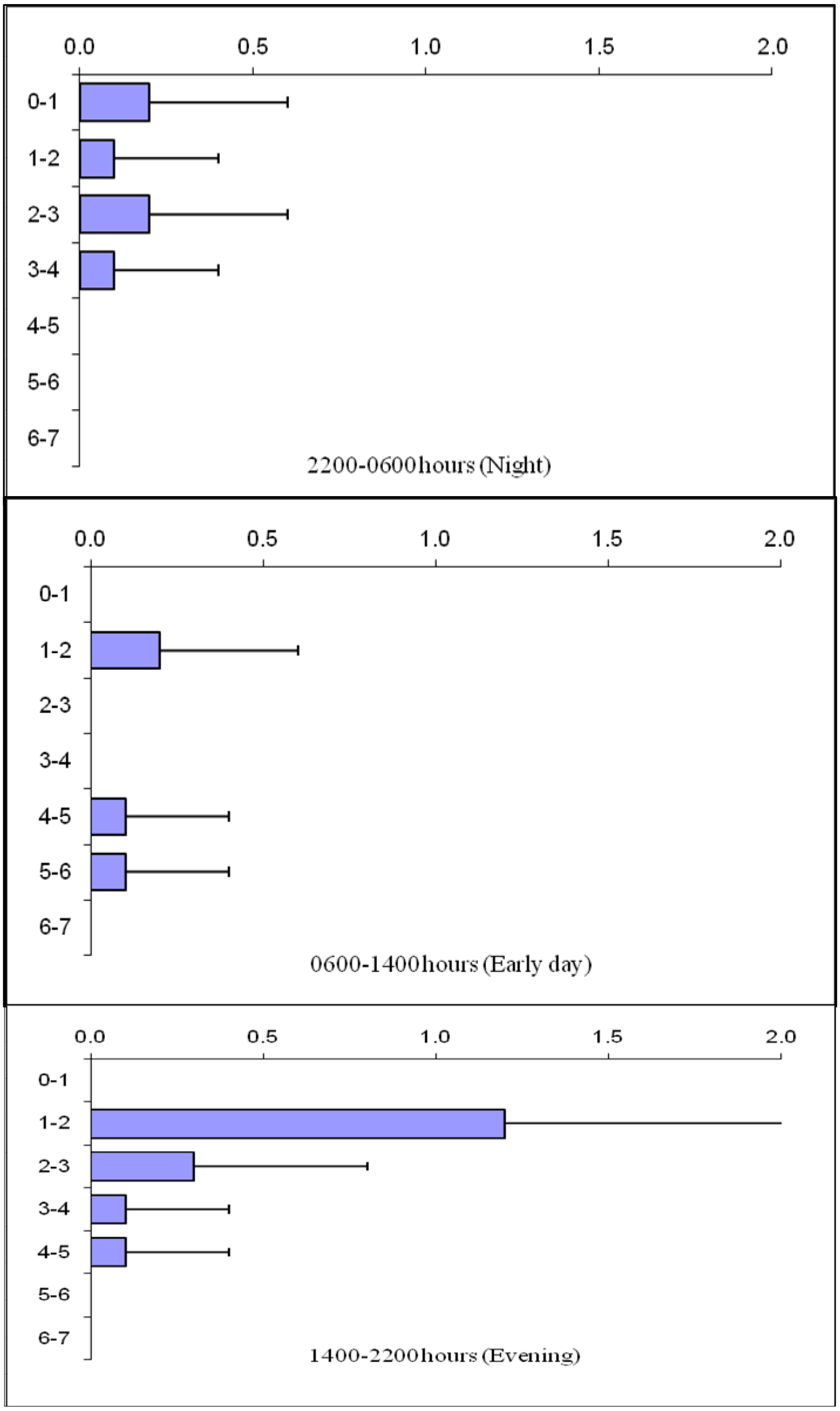


Figure 4.9(c) Mean vertical distribution of gillnet catches (ind./m^2) for *Hampala macrolepidota* calculated from 11 sampling sites of Tasek Bera. Error bars indicate the standard deviation.

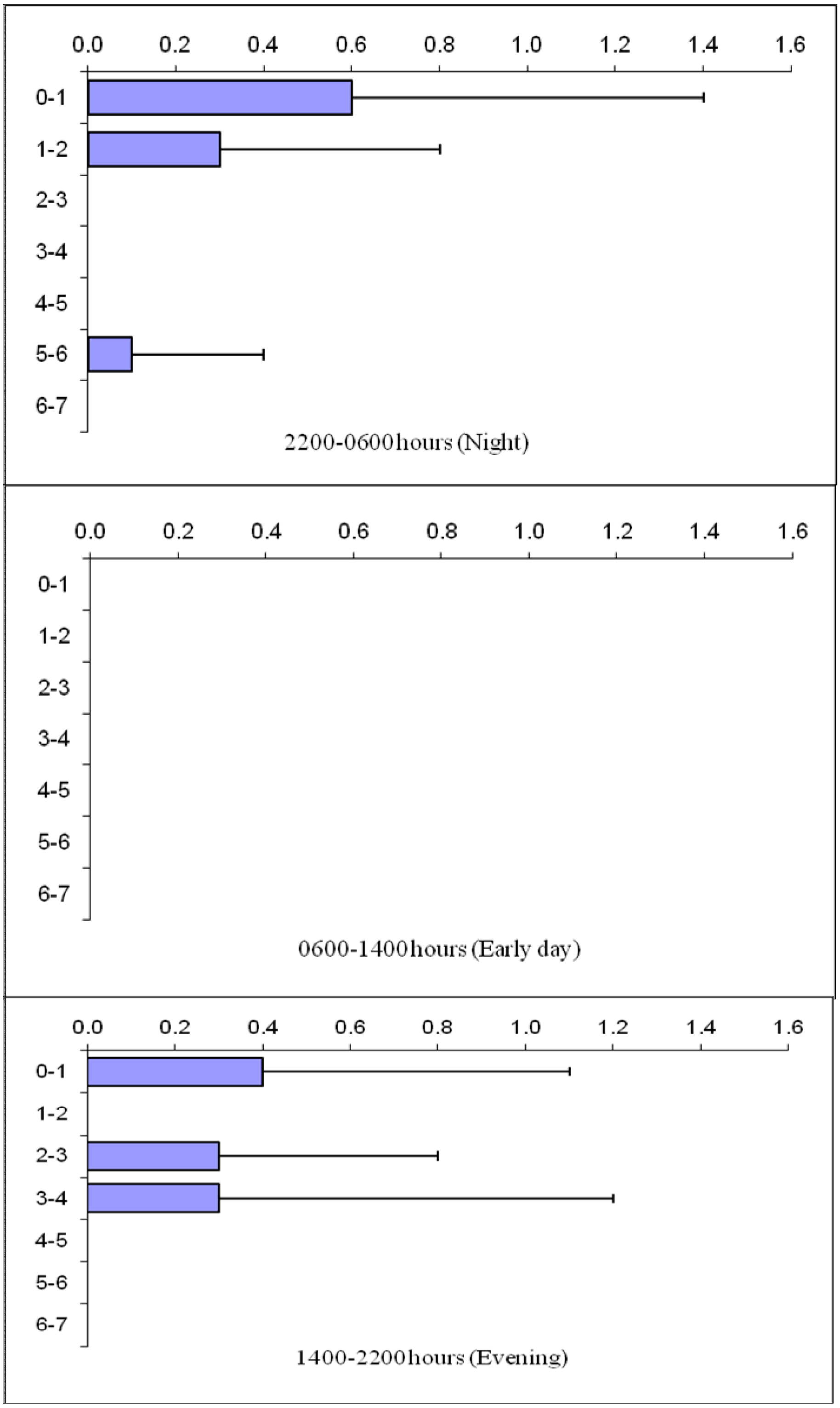


Figure 4.9(d) Mean vertical distribution of gillnet catches (ind./m^2) for *Kryptopterus apogon* calculated from 11 sampling sites of Tasek Bera. Error bars indicate the standard deviation.

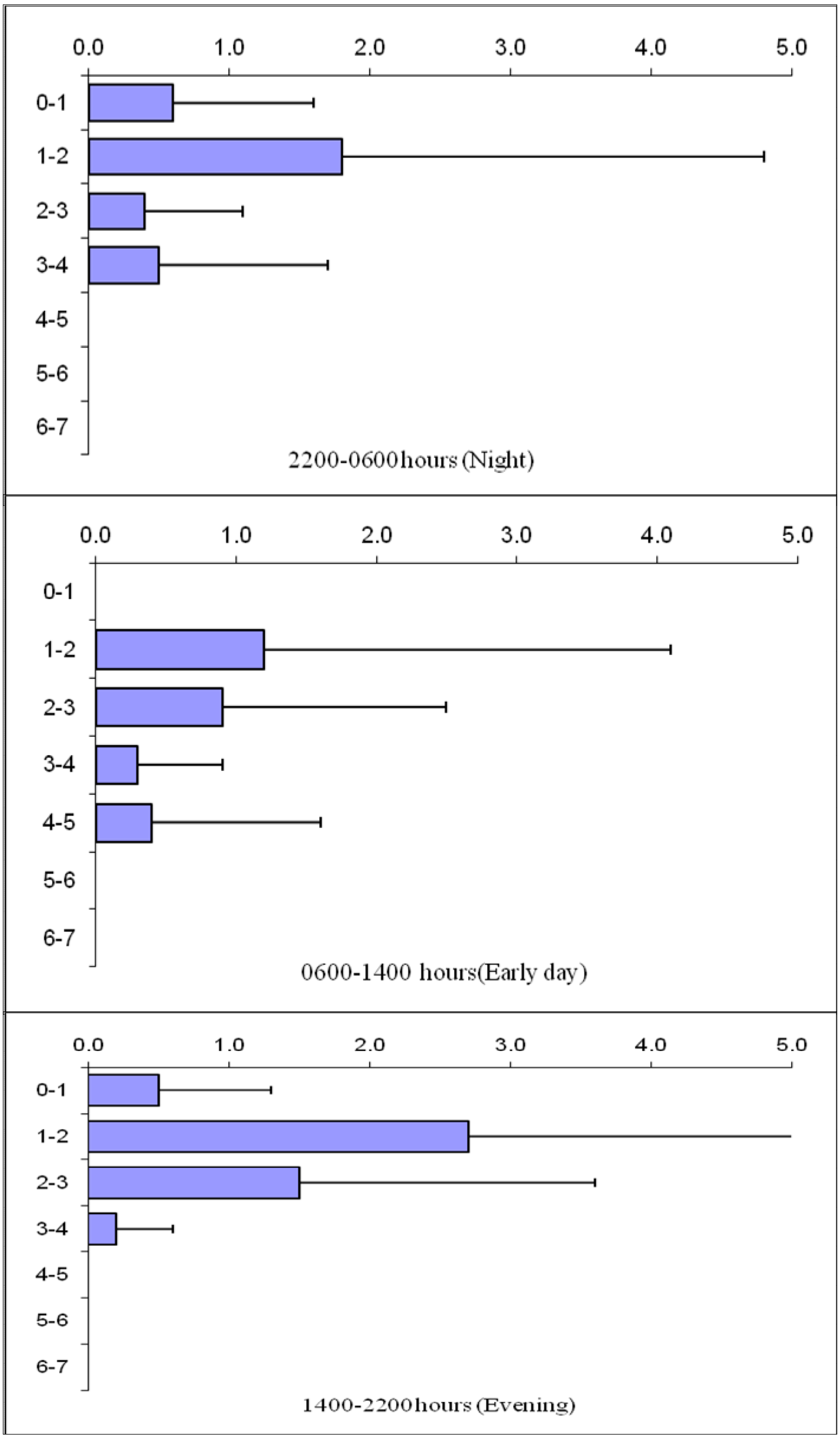


Figure 4.9(e) Mean vertical distribution of gillnet catches (ind./m^2) for *Labiobarbus festivus* calculated from 11 sampling sites of Tasek Bera. Error bars indicate the standard deviation.

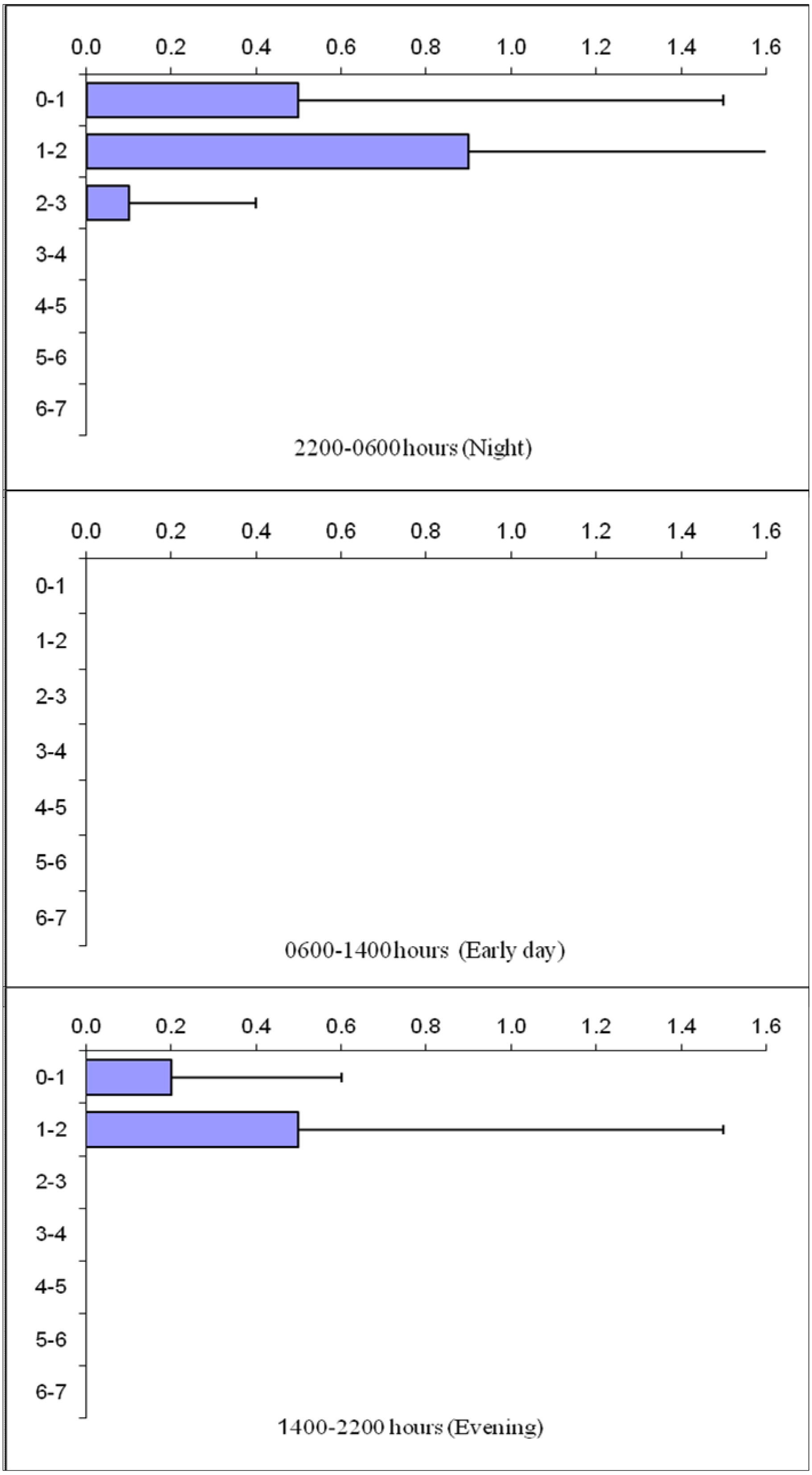


Fig. 4.9(f) Mean vertical distribution of gillnet catches (ind./m^2) for *Notopterus notopterus* calculated from 11 sampling sites of Tasek Bera. Error bars indicate the standard deviation.

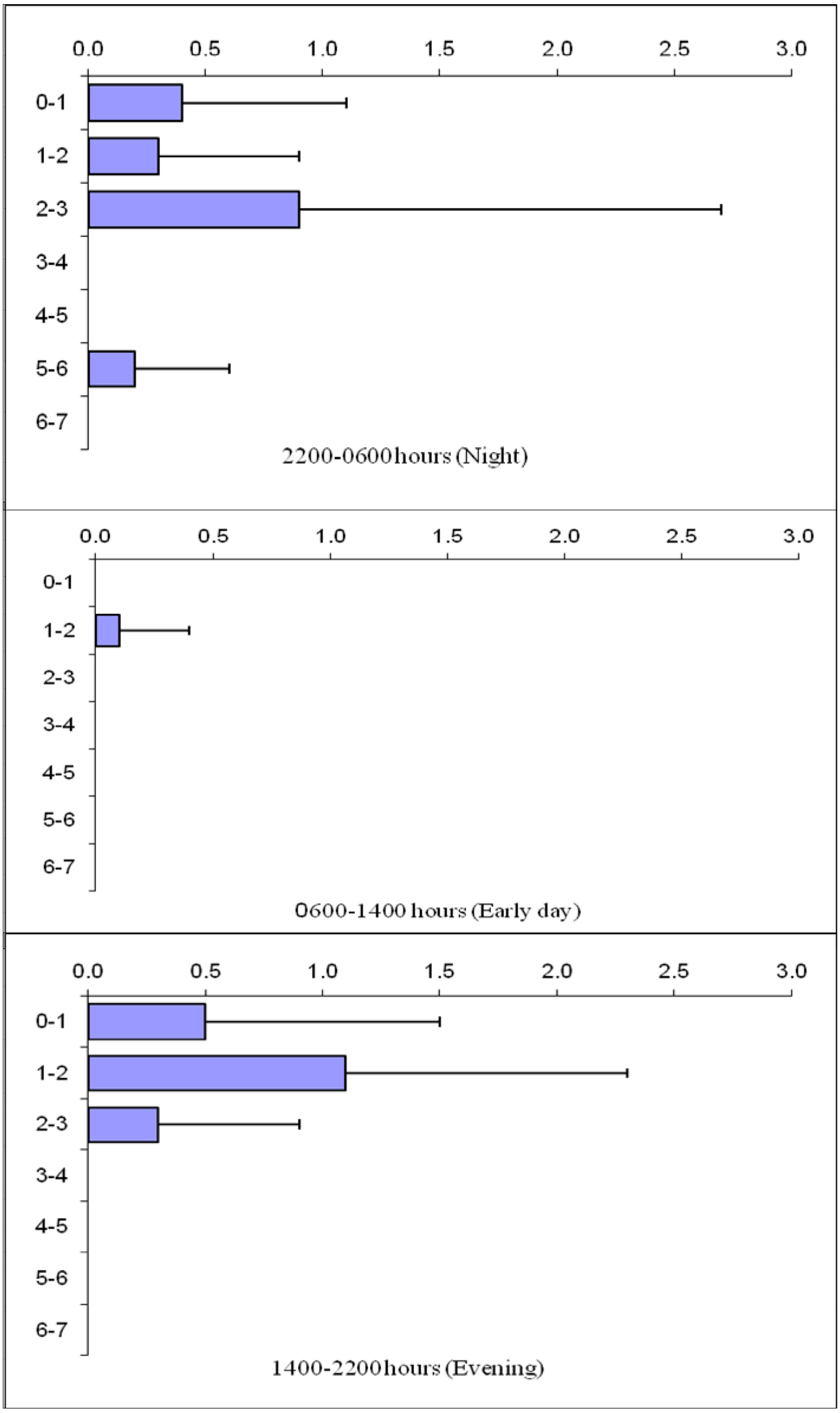


Figure 4.9(g) Mean vertical distribution of gillnet catches (ind./m^2) for *Osteochilus hasseltii* calculated from 11 sampling sites of Tasek Bera. Error bars indicate the standard deviation.

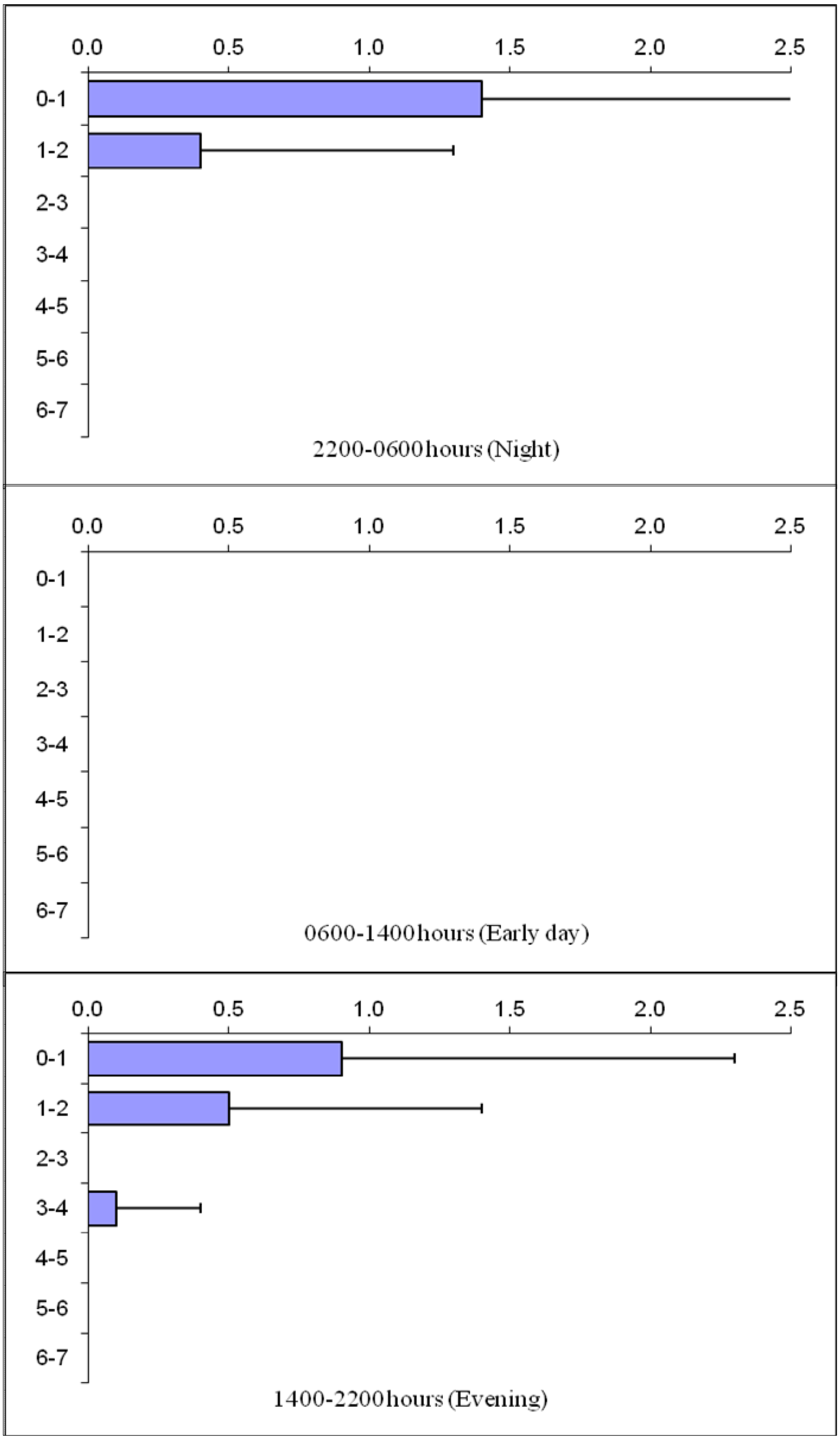


Figure 4.9(h). Mean vertical distribution of gillnet catches (ind./m^2) for *Oxygaster anomalura* calculated from 11 sampling sites of Tasek Bera. Error bars indicate the standard deviation.

Figure 4.10a & b shows the diel changes in the vertical distribution several of species which were caught in small numbers of (less than 17 individuals). In general only *L. trinema, O. waandersii, P. fasciata* and *T. thynnoides* were caught during all 3 different sampling times at depth less than 3 m from the surface (Fig. 4.10a). Eight individuals of *L. trinema* were caught forming the highest catch for early day sampling. *Osteocheilus melanopluerus* was caught during early day and evening periods. Three others species *C. oblongos, C. heteronema, K. limpok* and *O. hypopthalmus* were caught during evening and night time (Fig. 4.10a). About 40% of *C. oblongos,* and *C. heteronema* were caught during night time and for *O. hypopthalmus* and *K. limpok* almost 60% to 70% of the total catch were caught during evening time. *Kryptopterus limpok* was also a species caught in the deepest areas (7 m from surface), apart from *C. apogon*. *Chitala lopis, H. temminkii* and *P. apogonoides, P. oxygastroides, M. nigriceps* and *W. leerii,* were only caught during night sampling. *Osphronemus goramy* was caught only during early day (Fig. 4.10b).

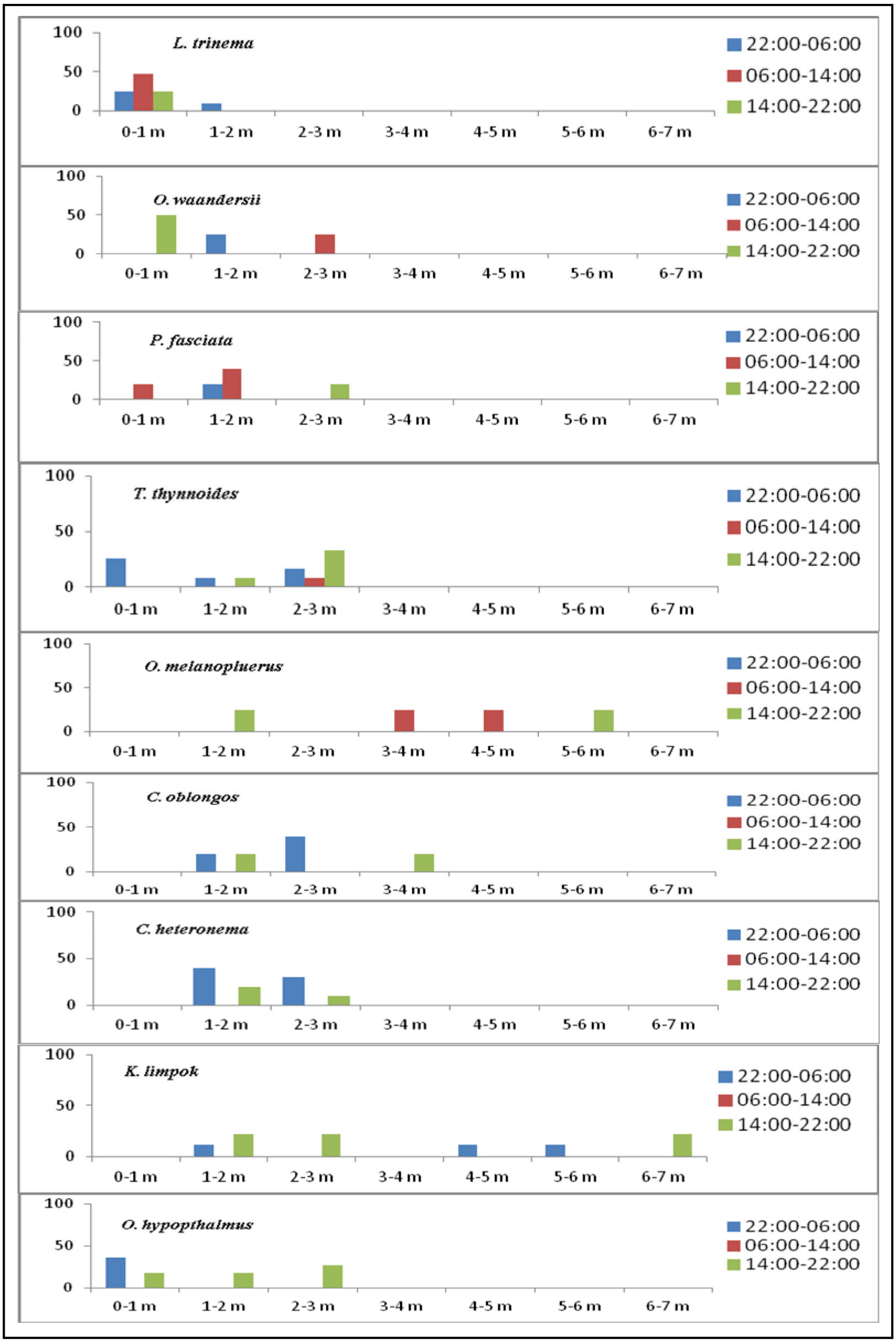


Figure 4.10a. Percentage of individuals caught for a particular species at a specific time and depth.

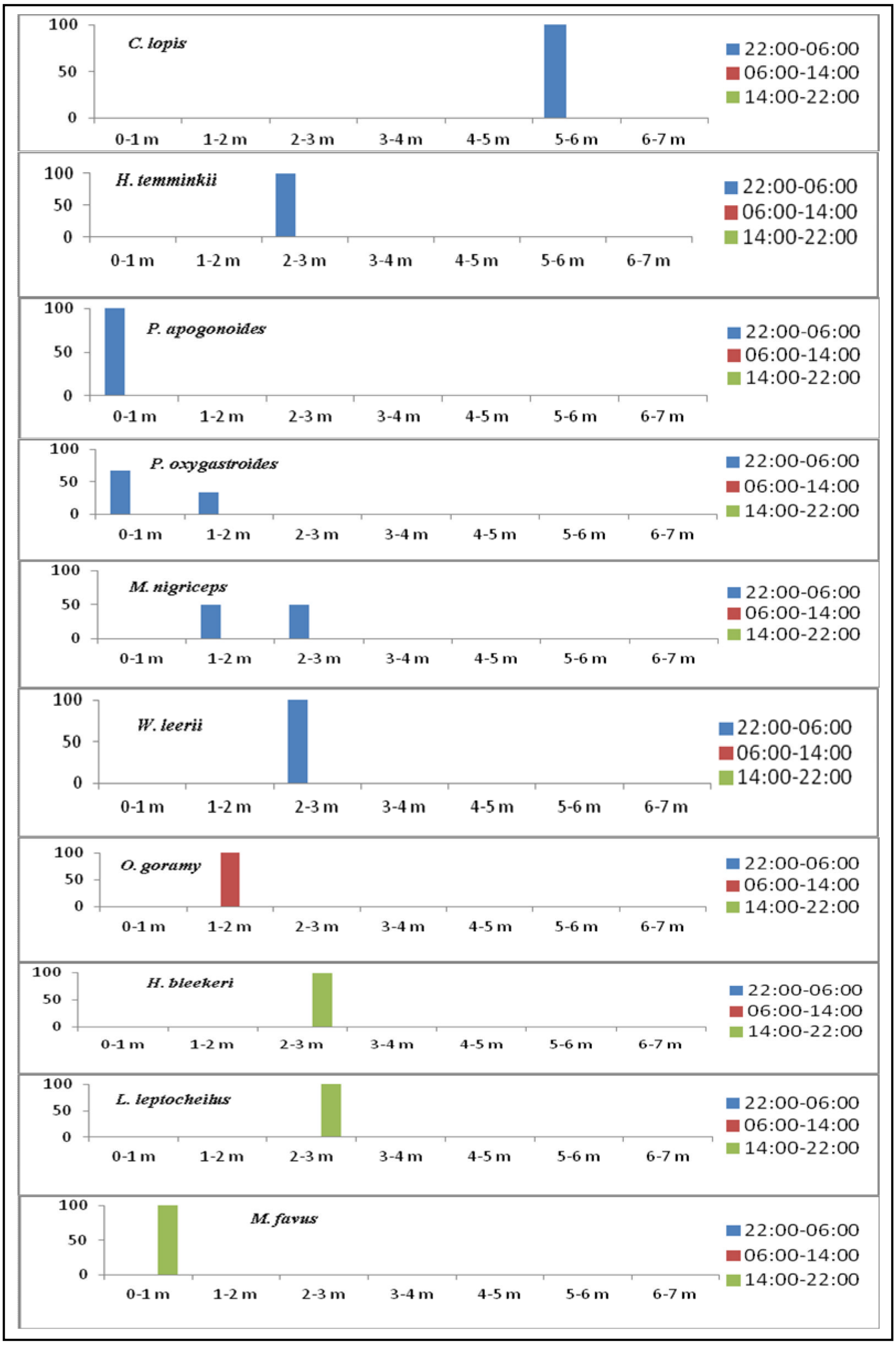


Figure 4.10b. Percentage of individuals caught for a particular species at a specific time and depth.

4.3.2.3 Pattern of species-environment relationship

Result of the canonical correspondence analysis (CCA) to investigate the pattern of species-environment relationship shows that the cumulative percentage variation of species data was very low, providing less than 3.8% of the variance, and the total variation of species-environment relation was 43.1%; 26.9% by the first axis and 16.2% by the second axis (Table 4.8). The eigenvalues of the first two CCA axes are 0.36 and 0.22, and the species-environment correlation for the same axes are 0.69 and 0.57 respectively. Monte Carlo permutation test (999 permutations under reduced model) of the first two axes indicate that both are statistically significant ($p<0.05$) contributions to explaining variance in the data of species abundance (Table 4.9). The CCA in Fig. 4.11(a) shows the correlation between the 11 sampling sites and eight environmental variables and Fig.4.11(b) shows the correlation between the 28 species and the environmental variables. Depth, dissolved oxygen and pH appeared as the most important parameters in the relationship, as their arrow lengths were the longest among all and this indicates their relative importance in explaining variation in species data. Out of eight variables tested with a Monte Carlo permutation test with 999 random permutation, five were found to be significant (depth, DO, pH, temperature and conductivity; $p<0.05$).

Súarez *et al.* (2004) had listed depth as one of the important factors regulating diversity and abundance of fish communities in Pantanal lagoon, Brazil. Table 4.10 show the correlations between environmental ordination axes and the environmental variables (intra-set correlation) which was shown by the length of the arrows in Fig. 4.11. Table 4.11 shows the correlations between the species ordination axes and the environmental variables (inter-set correlations). TSS and TDS show the strongest positive correlation with depth, whereas temperature has negative correlation with depth (Table 4.12).

Table 4.8 Eigenvalues and percentages of variance from canonical correspondence analyses of species and environmental variables of vertical distribution data

Axes		1	2	3	4	Total inertia
Eigenvalues	:	0.358	0.217	0.21	0.163	15.267
Species-environment correlations	:	0.694	0.567	0.544	0.49	
Cumulative percentage variance						
of species data	:	2.3	3.8	5.1	6.2	
of species-environment relation	:	26.9	43.1	58.9	71.2	
Sum of all eigenvalues						15.267
Sum of all canonical eigenvalues						1.331

Table 4.9 Summary of Monte Carlo test (499 permutations)

Test of significance of first canonical axis: eigenvalue = 0.358
F-ratio = 3.334
P-value = 0.0160

Test of significance of all canonical axes : Trace = 1.331
F-ratio = 1.659
P-value = 0.0020

Table 4.10 Intra-set correlations of environmental variables with environmental ordination axes. (Showed as the length of the arrows in CCA graph)

Axes	1	2	3	4
Depth	-0.820	-0.227	0.111	0.263
Temperature	-0.007	0.680	0.060	-0.577
TSS	-0.327	0.281	0.020	0.156
TDS	0.142	-0.100	0.221	0.526
Turbidity	-0.384	-0.459	-0.543	-0.109
Conductivity	0.171	0.405	0.370	0.621
DO	-0.090	0.701	0.016	-0.342
pH	-0.248	0.436	-0.645	0.039

Table 4.11 Inter-set correlation of environmental variables with environmental ordination axes.

Axes	1	2	3	4
Depth	-0.569	-0.129	0.060	0.129
Temperature	-0.005	0.386	0.033	-0.283
TSS	-0.227	0.159	0.011	0.076
TDS	0.099	-0.057	0.120	0.258
Turbidity	-0.266	-0.260	-0.295	-0.053
Conductivity	0.119	0.230	0.201	0.304
DO	-0.062	0.397	0.009	-0.167
pH	-0.172	0.247	-0.351	0.019

Table 4.12 Correlation coefficient between all environmental variables

	Depth	Temperature	TSS	TDS	Turbidity	Conductivity	DO	pH
Depth	1							
Temperature	-0.244	1						
TSS	0.283	0.060	1					
TDS	0.256	-0.397	-0.029	1				
Turbid	0.154	-0.293	0.164	-0.196	1			
Conductivity	-0.119	-0.002	-0.246	0.427	-0.485	1		
DO	-0.177	0.411	0.216	-0.052	-0.263	-0.012	1	
pH	0.170	0.053	0.320	0.028	0.112	-0.247	0.603	1

Depth was most strongly correlated with the first CCA axis (intra-set correlation is -0.82), whereas temperature and DO have less influences (intra-set correlation is -0.007 and -0.090, respectively) (Fig. 4.11a). The circles made in the diagram show the classification of samples according to the depth where the particular samples were taken. The first group consists of samples from the surface to 1 m depth concentrated on the right side of the diagram. Species like *Krytopterus apogon*, *Mastacembelus favus* and *Oxygaster anomalura* situated at the upper section were correlated to the environmental condition of higher DO, temperature and conductivity but lower turbidity (Fig.4.11b). *Mastacembelus* spp. can be found in a wide variety of habitats including peat swamp and also moving water areas but they often bury themselves during the day in the substrate sometimes for certain months, and coming out at night to feed on insect larvae, worms and vegetation (Nelson, 2006). This is probably why in present study the only individual of *M. favus* was caught during the evening sampling time at Lubuk Benal and coincidently caught at 0 to 1 m depth. The highest abundance of *Oxygaster anomalura* caught was very much influenced by higher conductivity. Khairul Adha *et al.* (2009) reported that this species dominate the brown waters of Batang Kerang in Sarawak, which also had higher conductivity. Johnson (1967b) has stated that this cyprinid is a surface-swimming fish. *Kryptopterus apogon* was caught mainly during evening and night time, as observed by Shiraishi *et al.* (1972) and as reported in Chapter 2, the maximum reading of conductivity was recorded at this time.

Species situated at the lower section of the diagram were *Luciosoma trinema, Ompok hypopthalmus* and *Parambassis apogonoides* (Fig. 11(b)). Species in this section shows that they prefer higher TDS but tolerated to lower DO, pH and TSS. *Luciosoma trinema* was the most abundant in this group, and it is one of the predatory fish in the Tasek Bera, feeding on insects and small fishes such as *Rasbora* sp. (Kottelat and Widjanarti, 2005). According to Kottelat and Widjanarti (2005) this species in widely distributed and very common during the dry season in the Kapuas Lakes Area (West Kalimantan), whereas in present study for Tasek Bera the situation is almost the same because almost 95% of total catch was found at the surface area during morning sampling (from 0600 to 1400 hours) when the highest temperature reached 31.0^{0}C. The distribution of *Ompok hypopthalmus* was mostly influenced by higher TDS. Similarly *K. apogon* (another silurid) was caught during evening and night time, when the time of maximum reading of TDS was recorded. *Parambassis apogonoides* is a small species with maximum length of about 10.0 cm SL (Kottelat *et al.,* 1993) and thus difficult to catch using the vertical gill nets of three different mesh sizes used (2.5 cm, 5.1 cm and 7.6 cm) in this study. Kottelat and Widjanarti (2005) and Baran *et al.* (2005) reported that this species is most common in the dry season in the Kapuas Lakes Area (Kalimantan) and the Knone Falls, Mekong River (Southern Laos), respectively. There was only one individual of this species caught during night time, when the temperature was relatively low.

The second group build by the CCA in Fig. 4.11(a) consist of samples from 1 m to 2 m depth from the surface. With highest number of species and abundance, this group showed the most ideal environmental conditions for species caught in Tasek Bera area (Fig. 4.11b). Species like *Cyclocheileichthys apogon, C. heteronema, Hampala macrolepidota, Labiobarbus festivus, Osteocheilus hasseltii* and *Notopterus notopterus* are found near to the origin of the arrows which is the average of each of the environmental variables and that suggesting a weaker association between those species with the environmental variables. *C. apogon, H. macrolepidota, L. festivus* and *O. hasseltii* are also the most common species in the present study. Johnson (1967b) reported that *C. apogon* and *O. hasseltii* often occur together, sometimes in mixed schools, however both are different in their food requirements. The former is insectivorous and the latter a vegetarian detritus feeder. *Pristolepis fasciata* and *N.*

notopterus show high correlation with DO even though both species have high resistance to low DO concentration (Lambert, 2001), however *N. notopterus* shows some attraction to areas of high conductivity (close to the conductivity arrow). The same correlation has been reported by Tongnunui and Beamish (2009) for *N. notopterus, C. apogon* and *O. hasselti* in small rivers in eastern Thailand.

Hampala macrolepidota together with *Crossocheilus oblongus, Hemibagrus bleekeri, Labiobarbus leptocheilus, Chitala lopis* and *Wallago lerii* are associated with depth as most of the species has been caught at depth up to 6 m from the surface and can be considered as benthic fishes. All of them are carnivorous feeding on insect and other fishes except for *L. leptocheilus* and *C. oblongus*, which are omnivorous and algae eater, respectively. Even though these species could tolerate lower pH and DO but they were less abundant compared to others. Johnson (1967a) said that cyprinids fish are most important in the acidic and relatively unproductive forest-stream and blackwater habitats and less important in the productive riceland habitats. Low oxygen level especially at night may be one of the important factors restricting the distribution of many species. Tongnunui and Beamish (2009) placed *H. macrolepidota* in a benthic group where the substratum was rocky with plentiful benthic invertebrates on which they could feed. Zakaria-Ismail and Sabariah (1995) reported that this species was the most common and successful species caught in almost all depths including the deepest layer at Temenggor Lake which have very low DO, lower temperature and pH, that suggest that this species has high tolerance to low DO, temperature and pH. From the CCA in Figure 4.11b show that *C. oblongus* and *L. leptocheilus* also show the same preference as *H. macrolepidota*. Beamish *et al*. (2006) identified temperature and oxygen as significant variables influenced the distribution of Cyprinidae in small rivers in Central Thailand.

Barbonymus schwanenfeldii, Mystus nigriceps, Osphronemus goramy, Osteocheilus waandersii and *Parambassis siamensis* in Figure 4.11(b) are situated along Axis II at the lower area of the graph. They show resistance to low pH, DO, temperature and conductivity as well as higher TDS, depth, and turbidity. Some of them are predators, thus higher turbidity means better chances to catch prey as shown by Chiu and Abraham (2010) with regards to fathead minnow (*Pimephales promelas*). Tamatamah (2007) placed *Osphronemus* in the same group as other genera which are tolerant to low dissolved oxygen concentrations or even to anoxic conditions tolerated by *Mastacembelus* and *Clarias*. *Mystus nigriceps* from the family Bagridae known as an air-breather, tolerant to low DO and low pH levels. Khairul Adha *et al.* (2009) also reported the same adaptative ability for Bagridae in Batang Kerang floodplain swamp area.

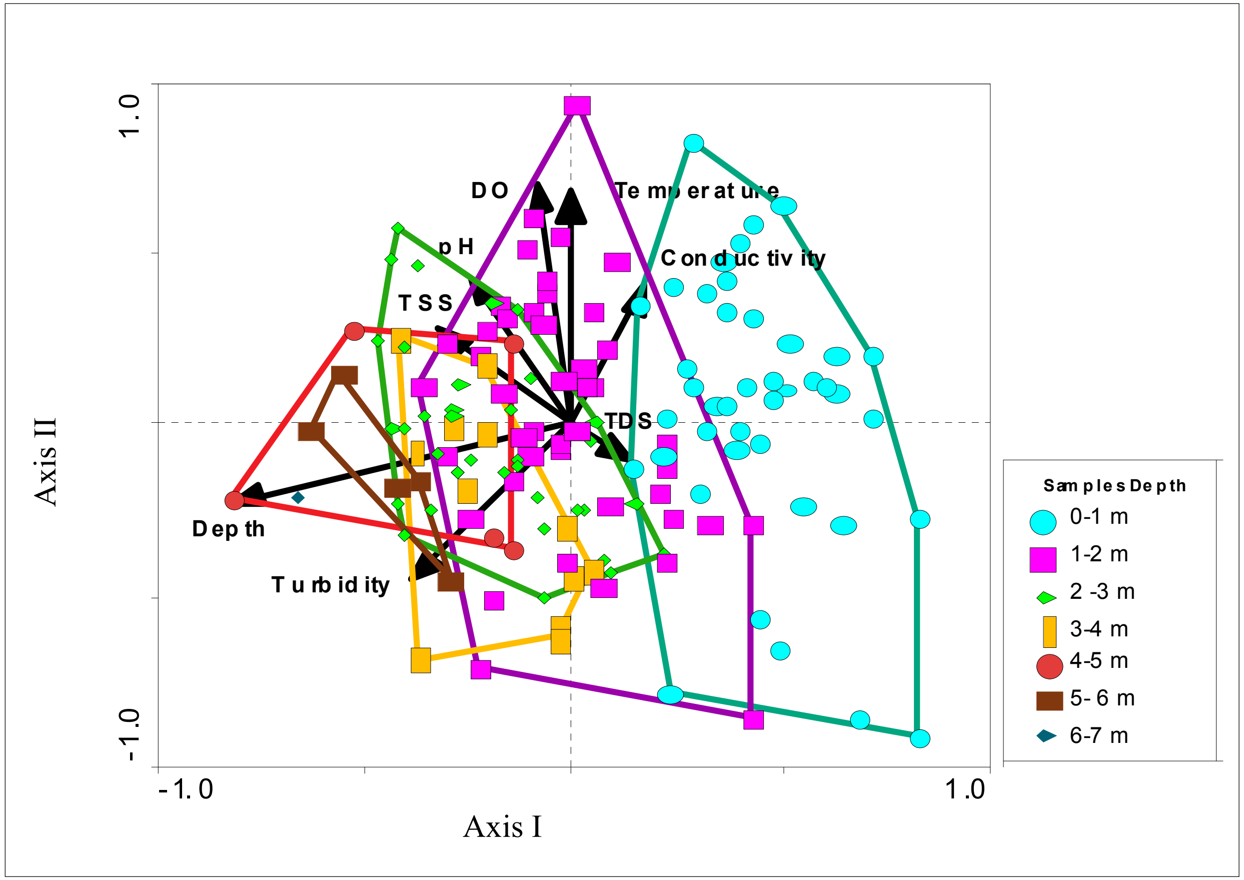


Figure 4.11(a) Canonical correspondence analysis axes I and axis II, showing the association of samples to eight environmental variables. The samples have been classified according to the depth of those particular samples taken.

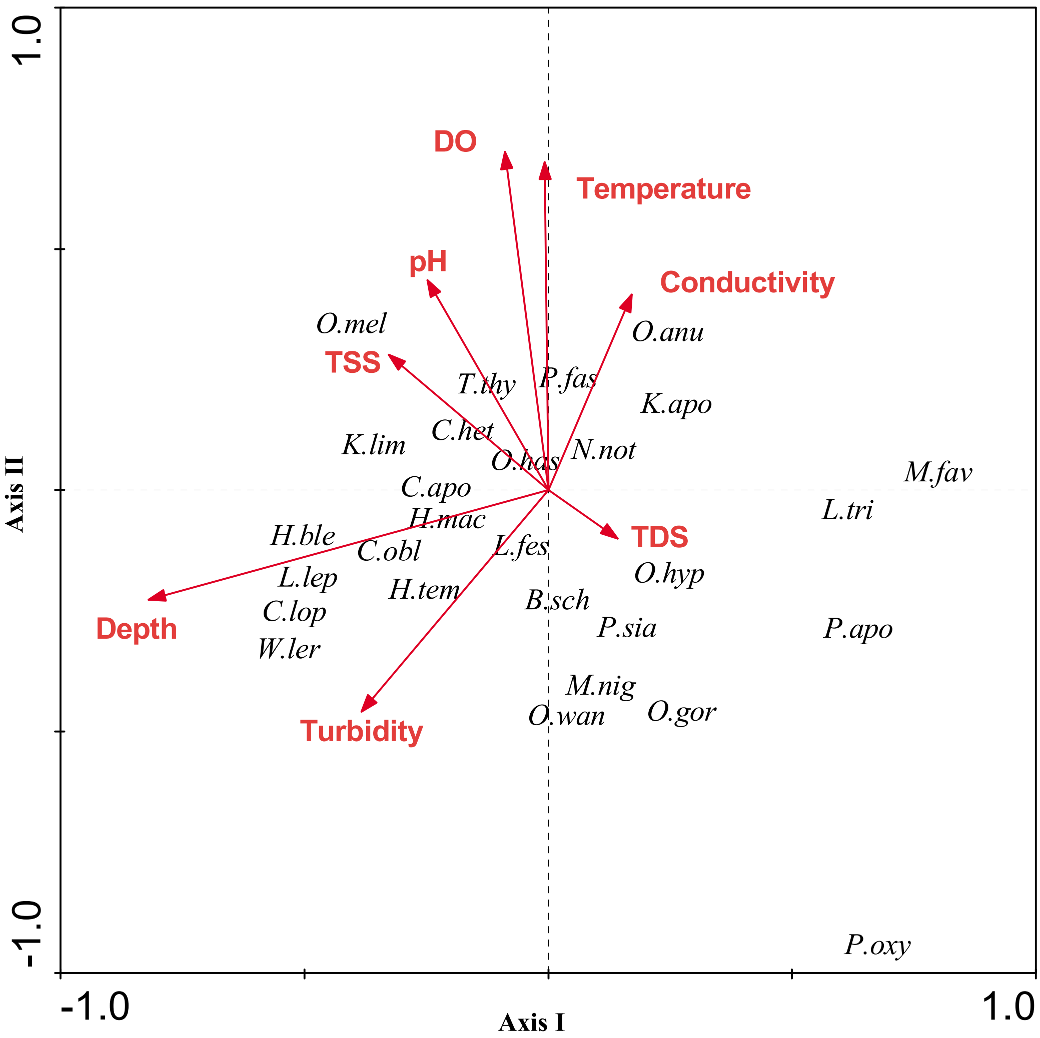


Figure 4.11(b). Canonical correspondence analysis axes one and two, showing the association of fish species to eight environmental variables. Species abbreviations: *B.sch= Barbonymus schwanenfeldii; C.lop= Chitala lopis; C. obl= Crossocheilus oblongus; C. het= Cyclocheilichthys heteronema; C.apo=Cyclocheilicthys apogon; H. mac= Hampala macrolepidota; H.tem=Helostoma temminkii; H.ble= Hemibagrus bleekeri; K.apo= Kryptopterus apogon; K.lim= Kryptopterus limpok; L. fes= Labiobarbus festivus; L.lep= Labiobarbus leptocheilus; L.tri= Luciosoma trinema; M.fav= Mastacembelus favus; M.nig= Mystus nigriceps; N.not= Notopterus notopterus; O.hyp = Ompok hypopthalmus; O.gor= Osphronemus goramy; O.has= Osteocheilus hasseltii; O.mel= Osteocheilus melanopluerus; O.wan= Osteochilus wandersii; O.anu= Oxygaster anumalura; P.oxy= Parachela oxygastroides; P. apo= Parambassis apogonoides;P. sia= Parambassis siamensis; P.fas = Pristolepis fasciata; T.thy= Thynnichthys thynnoides; W.ler= Wallago leerii.*

CHAPTER 5

FEEDING BIOLOGY AS BASIS OF THE SUCCESS OF *LABIOBARBUS FESTIVUS* IN TASEK BERA

5.1 INTRODUCTION

Labiobarbus festivus was the most abundant species throughout Tasek Bera and was caught throughout the year (Chapter 4). Why is this species so successful? I believe that the diet of a particular species is the main factor of its abundance in Tasek Bera. Wootton (1992) has stated in his book that the high species diversity of cichlid in the Great Lake of Africa, Malawi, Tanganiyka and Victoria is associated with a wide adaptive radiation in feeding ecology. Studied by Motta (1988) on 10 different species of butterfly fishes with difference mouth morphology and diet discovered that even species with morphologically specialised diet would switch from feeding on their usual food to take zooplankton when it was abundant. In my study, the mouth part of *L. festivus* was scanned using electron microscope. By looking at the microscopic structure such as taste buds and unculi which situated at the certain part of the lips and jaws provide an understanding on it feeding biology.

This chapter discuss the feeding biology of the most commonly found fish species in Tasek Bera, *Labiobarbus festivus*. Nagai *et al*., (1972) gave a brief qualitative report on the feeding habits of some of the fish in Tasek Bera and they believed *Labiobarbus* sp. to be a herbivore based on the length and coils of the intestines. Mizuno and Furtado (1982) reported *L. festivus* as phytophagous, which feed only on algae and aquatic macrophytes such as *Utricularia, Staurastrum* and *Closterium* in Tasek Bera. Kottelat and Widjanarti (2005), reported *L. festivus* feed on zoobenthos (such as insects), detritus and debris in Kapuas Lakes Area, western Borneo Indonesia. More intensively studied at Bukit Merah Reservoir, Malaysia, Yap, (1988) presumed that this species to be a detritivore, feeding mostly on algae, crustacean and detritus (each contributing more than 30% of the stomach contents composition). Lowe-McConnell, (1975) who studied fish communities in tropical freshwater said that only a small percentage of fishes are detritivores, with some of them taking detritus as an alternative when preferred food are scarce. As detritus feeders, they possess special adaptations in their gut morphology, feeding behaviour and digestive system in order to extract nourishment from the organic waste material that consist of decomposing plants or animals (Bowen, 1983 and Gerking, 1994). The relationship between the morphology of the digestive apparatus and diet of fishes have been well reported by Al-Hussaini (1949), who concluded that the mouth, teeth, gills, stomach and intestine are closely related to the diet of the fish. In this study, information was gathered in order to understand the feeding strategy of this particular species as it is the most successful species of fish throughout Tasek Bera.

5.2 TAXONOMIC NOTE

Kingdom : Animalia

Phylum : Chordata

Subphylum : Vertebrata

Class : Actinopterygii

Subclass : Teleostei

Order : Cypriniformes

Suborder : Cyprinoidea

Family : Cyprinidae

Subfamily : Cyprininae

Tribe : Labeonini

Subtribe : Labeones

Genera : Labiobarbus

Species : *Labiobarbus festivus*

Labiobarbus festivus (Heckel, 1843) belongs to the family Cyprinidae and abundant in term of numbers only in Tasek Bera and Tasik Chini in Pahang (Khan *et al*., 1996). Revision by Robert (1993) documented the complete diagnosis on this species which previously named as *Cyrene festiva* Heckel, 1843; *Dangila festiva* Bleeker, 1857 and *Dangila festiva* var. *Stercusnuscarum* Vaillant, 1902. It has black marginal stripe, a broad red submarginal stripe and black spots at the base of the dorsal fin rays. The caudal fin is black with broad red marginal stripe. It is also has a dark longitudinal stripes on the body and sometimes extend to all scale rows on side of body below lateral line.

5.3 MATERIALS AND METHODS

5.3.1 Study site and sampling method for stomach contents

A total of 54 adult *L. festivus* were collected at Tanjung Penarikan (SL 110.00 mm - 125.00 mm) using gill net with mesh size of 51.00 mm. The mouth and associated orals organs were examined and photographed. The whole alimentary tract was dissected out of the fish, uncoiled and the length measured. Only the first 5 cm of the anterior part of the stomach was opened and observed under a low-powered binocular microscope (Fig. 5.1(a & b)) with eyepiece scale in the form of square grids measuring 1 x 1 mm per square. The contents were picked out on to a Sedgewick Rafter (Fig. 5.2) counting cell (volume 1.0 mL) and the total volume of the content determined. The contents were then transferred into a 10 mL vial filled with 10% formalin up to 1 mL and stirred in order to break up the foods bulk. Only 1.0 mL of this mix was transferred on to a Sedgewick Rafter cell and the food items examined under magnification up to 100x (modification to method from Hynes,1950; Hellawell & Abel, 1971). The examination was repeated five times for each individual. Each food item was identified as far as possible (to the lowest taxonomic level), enumerated and the volume present in the samples estimated. Identification of algae was following Salleh, (1996) and zooplankton followed Idris (1983). The importance of each food item in the diet was obtained by the Relative Importance Index (RIa) followed George and Hadley, 1979.

$$RI_a = \frac{100\ AI_a}{\sum_{a=1}^{n} AI_a}$$

AI_a = the percentage of volume + percentage of number + percentage frequency of occurrence, for food item "a", and

n = the number of different food types.

Figure 5.1(a) Digestive tract of *Labiobarbus festivus*

Figure 5.1 (b). The first 5.0 cm anterior part of the stomach used for stomach content study

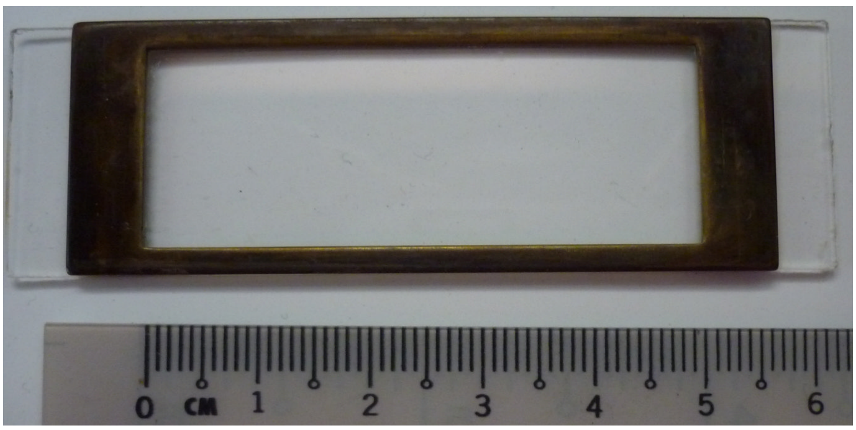
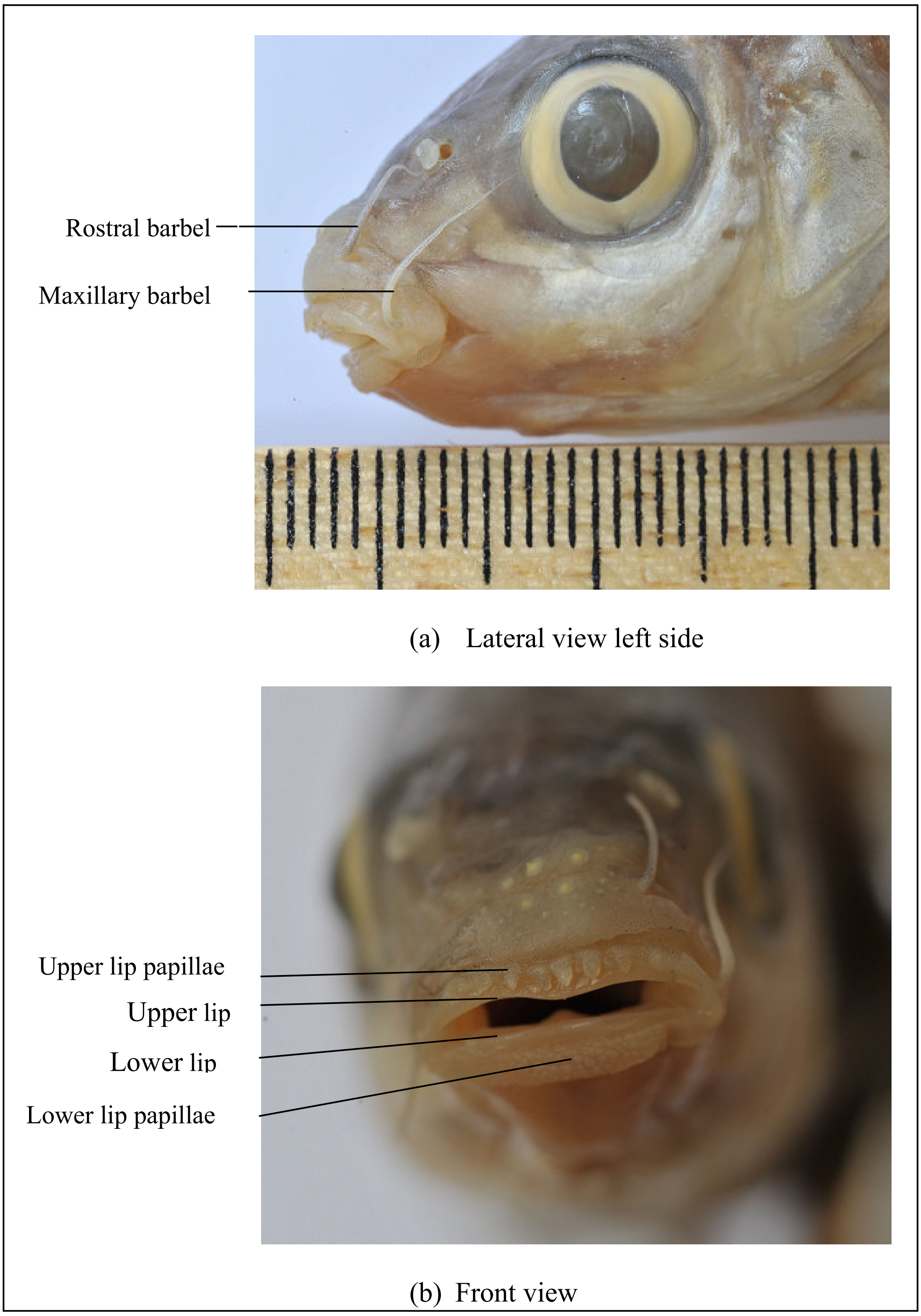


Figure 5.2. Sedgewick Rafter cell (volume 1.0 ml)

5.4 RESULTS AND DISCUSSION

5.4.1 Mouth and associated oral organs

In *Labiobarbus festivus,* the mouth is inferior with upper and lower jaws protrusive and toothless (Fig. 5.3a). Kottelat *et al*., (1993) suggested that fishes with inferior mouths probably feed on detritus or invertebrates living among the bottom substrate or on algae scraped off rocks. Toothlessness is one of the adaptations for the detritivorous fish (Veregina, 1990). Fugi *et al*., (2001), stated that species which consumed mud and fine particulate detritus, (*Prochilodus lineatus* and *Steindachnerina insculpta*), have no teeth as they do not need the structure to ingest or hold the food. As a cyprinoid, this species also show the unique morphology of the lips and associated structures, with horny sheaths (unculi) on the jaws. Robert (1982) described unculi as horny projections arising from single cells and possible functions include mechanical protection of the skin, rasping, adhesion and hydrodynamic effects. Furthermore, he also believed that the unculi is very important in the diversification of cyprinoid feeding habits and in the adaptation of bottom-dwelling cyprinoids and siluroids to swift-water habitats, especially in Asia. Roberts (1993) described the genus *Labiobarbus* as having two pairs of barbells (rostral and maxillary), upper lip thin with a linear series of papillae, lower jaw with moderately developed horny jaw sheath separate from lower lip, lower lip thin, with scattered papillae and lips lacking unculiferous ridges.



(a) Lateral view left side

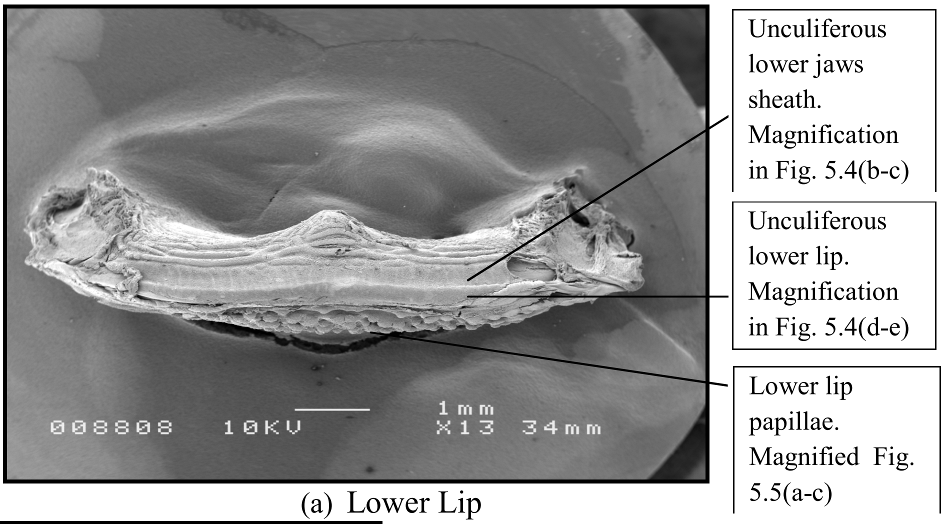
(b) Front view

Figure 5.3 Morphology of the mouth parts of *Labioabarbus festivus*

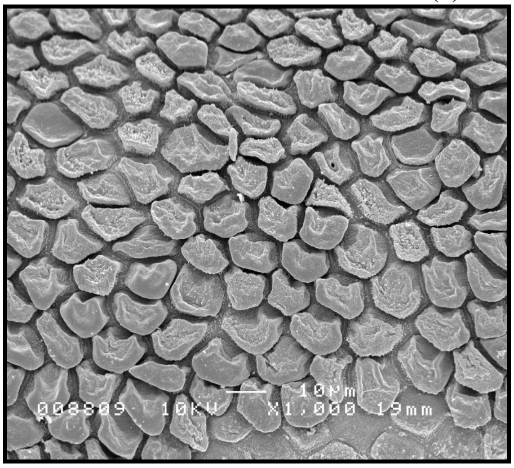
Figure 5.4a shows a SEM micrograph of the lower lip of *L. festivus*. The lower jaw has truncate unculi with polygonal borders projecting downward (Fig. 5.4(b-c)). The surface of lower lip also covered with unculi but smaller in size and some show hemispherical shape projecting upward (Fig. 5.4(d-e)). Lower lip also has papillae complete with taste buds (Fig. 5.5(a)). The taste buds were located at the peak of each papillae protrusion (Fig. 5.5(b-c)).

Figure 5.6(a) shows SEM micrograph of the upper lip of *L. festivus*. The papillae on the upper lips are equipped with taste buds (Fig. 5.6(b)) and the upper lip is not accessorised with unculi (Fig. 5.6(c)) unlike the lower lip. The upper jaw however has truncate unculi with polygonal border (Fig. 5.6(c-d)). Figure 5.7 shows the palate area scattered with taste bud at the front and microridges (maze like pattern) area at the back.

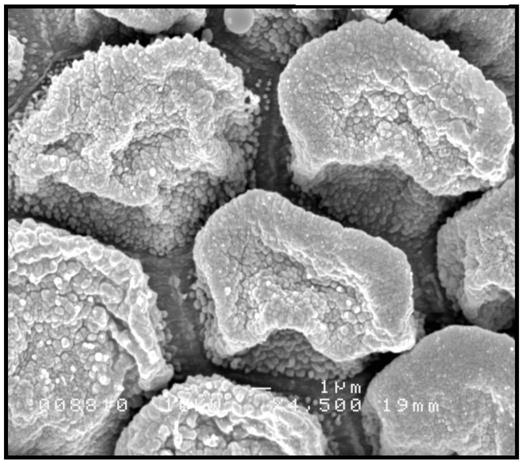
Robert (1982) suggested that unculi on the lips of various cyprinoids involved exclusively in feeding or both feeding and adherence to the substrate. For *L. festivus* the unculiferous lower lip and jaws have a rasping function as in many cyprinoid which feed on algae. The unculiferous surfaces probably work against each other or against the substrate during feeding. Tripathi and Mittal (2010) concluded from the histochemical methods that the horny jaw or unculi as they are referred to by Roberts (1982) of *Puntius sophore,* an omnivorous fish are mainly proteinacious and they considered this extremely strong protein (keratin) structure as sharp cutting structure, an adaptation to find or scrape food materials, e.g. algal felts and mats growing on the substratum. Roberts (1989) in his book on freshwater fishes of Western Borneo stated that *Osteochilus hasselti* has unculiferous lips from the SEM which may possibly be the reason for chopped up bits of filamentous algae which he found in the stomach contents. Agrawal and Mittal (1992a & b) suggested that this structure on *Labeo rohita* and *Cirrhina mrigala* may also provide additional strength and protection to the epithelia especially from abrasion behaviour during feeding time. Pinky *et al*., (2002 and 2004) also made the same suggestion for stream fish *Garra lamta*.



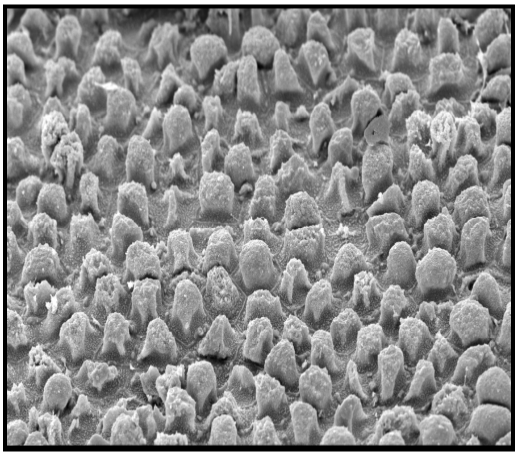
(a) Lower Lip



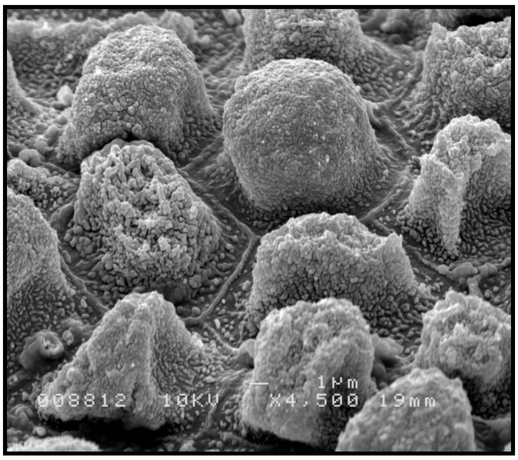
(b) Truncate unculi lower jaw.
Magnified 1000X



(c) Truncate unculi lower jaw.
Magnified 4500X



(d) Unculi lower lip
Magnified 1000X



(e) Unculi lower lip
Magnified 4500X

Figure 5.4 SEM photo of lower lip of *Labiobarbus festivus*.

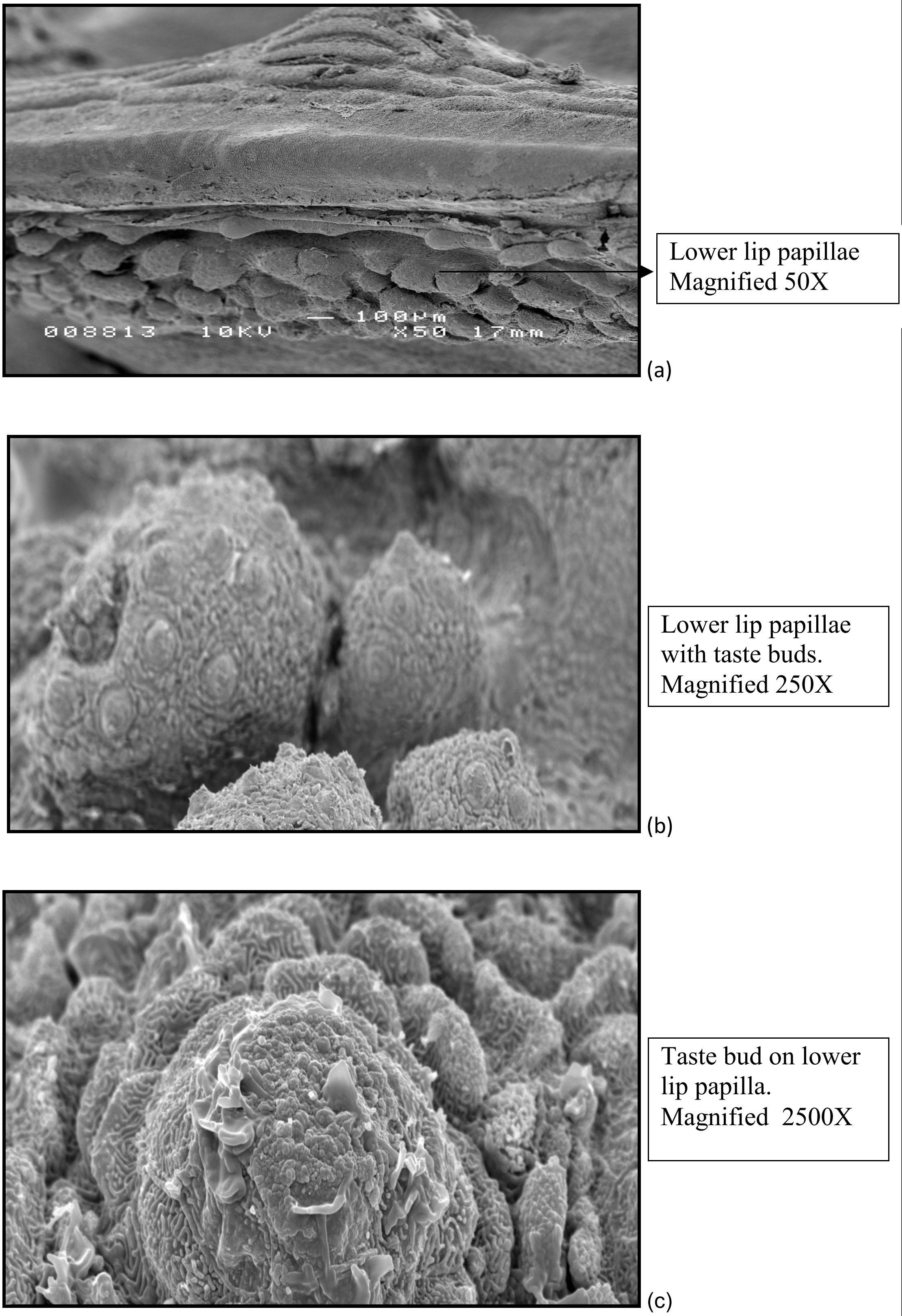
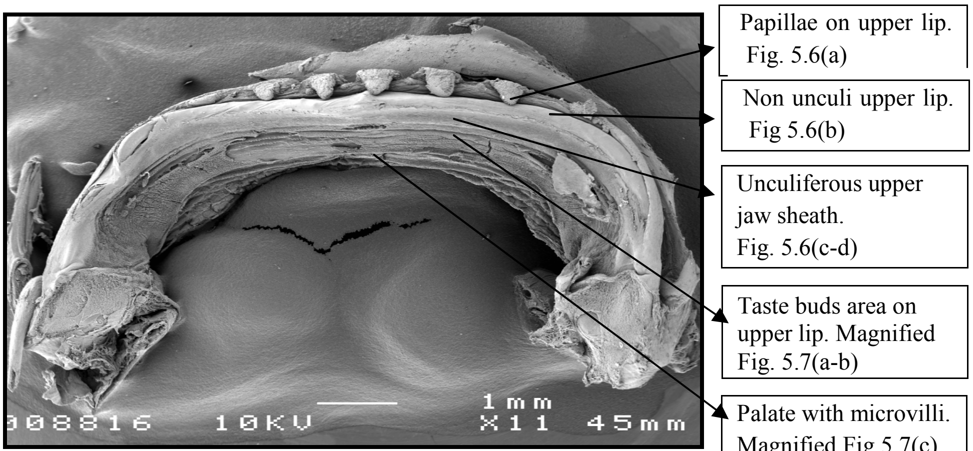
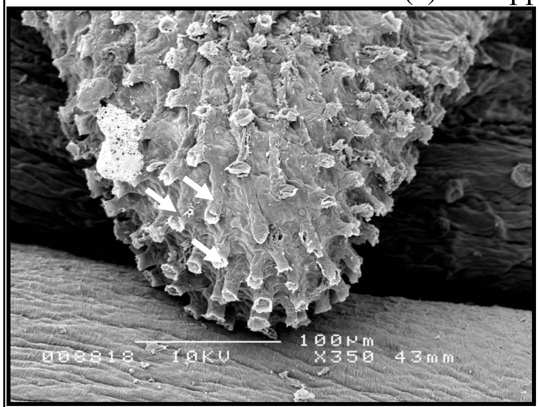


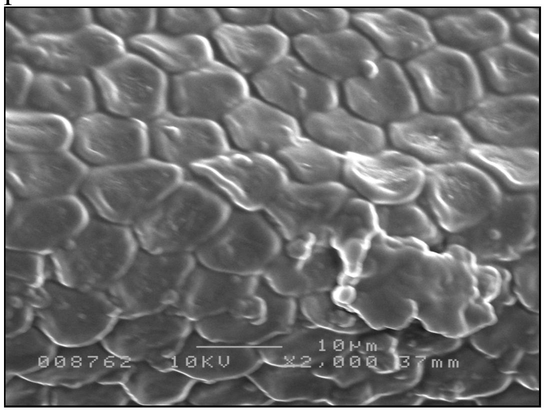
Figure 5.5 SEM photo of lower lip papillae of *Labiobarbus festivus.*



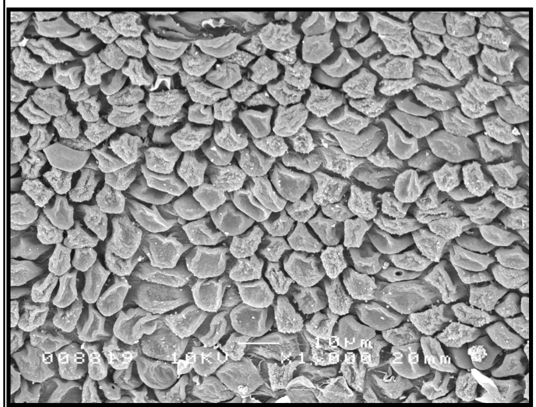
(a) Upper lip



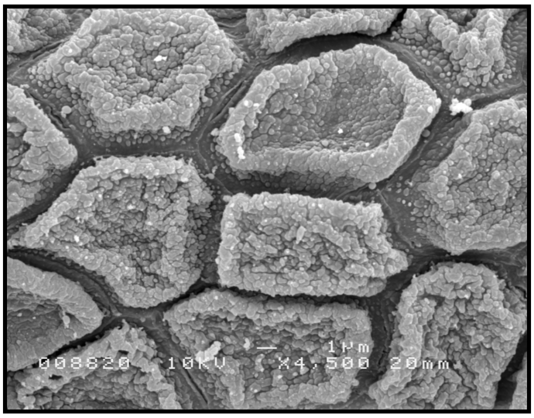
(b) Papillae upper lip x 350
Arrows shows some of the taste buds



(c) Non-unculi upper lip x 2000

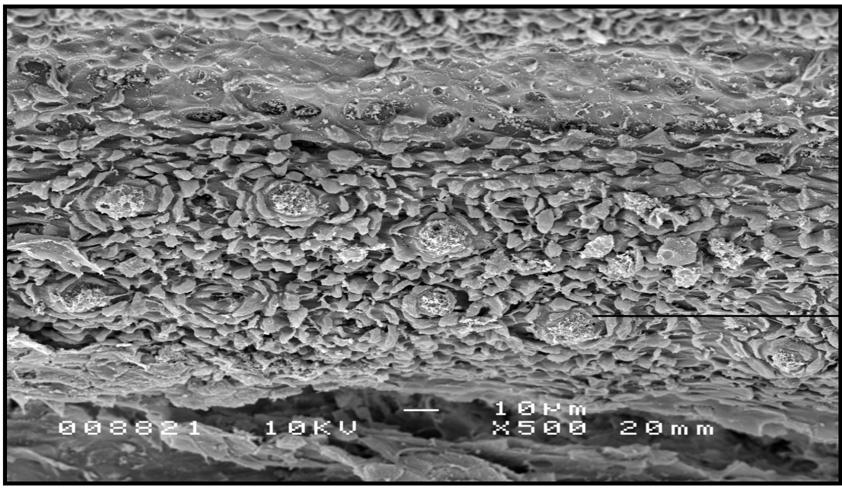


(c) Truncate unculi upper jaw x 1000

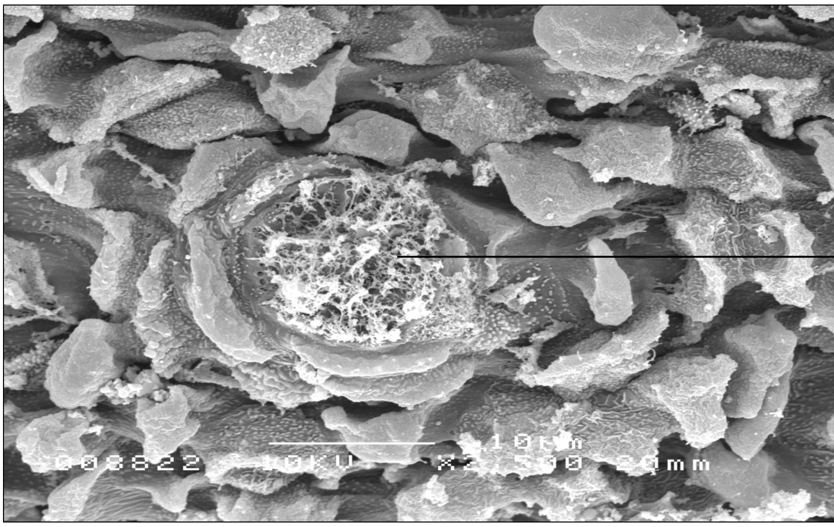


(d) Polygon unculi upper jaw x 4500

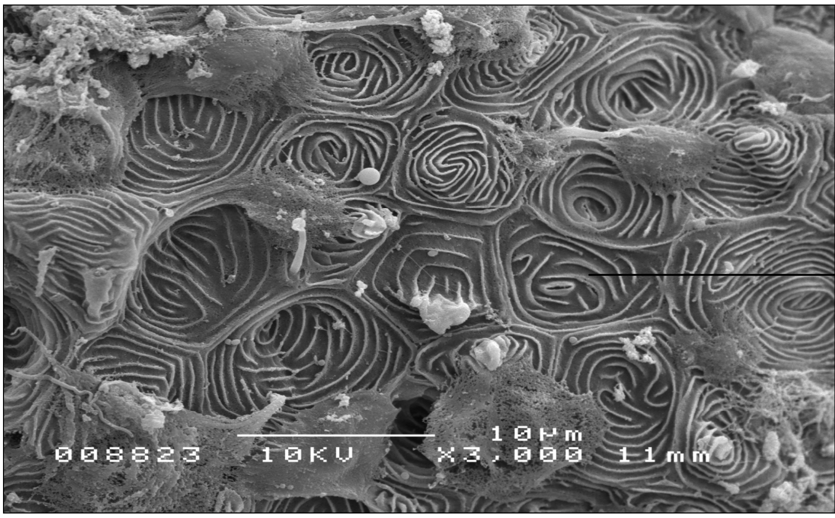
Figure 5.6 SEM photo of upper lip of *Labiobarbus festivus*



(a) Taste buds x 500



(b) Taste bud magnified 2500X



(c) Microvilli magnified 3000X

Figure 5.7 Taste buds on palate at upper lip

It is generally known that fishes have specialised taste organs in the epidermis of the mouth and associated oral organ (Reutter, 1974; Kiyohara *et al*., 1980; Kiyohara *et al*., 1984; Komada, 1993; Yashpal *et al*., 2006; Tripathi and Mittal, 2010). In *L. festivus*, the presence of taste buds on papillae of upper and lower lips and palate area could be considered as an adaptation as a detritivore, in order to select its food from among the substrate. The taste buds are located on a small epithelial papillae projecting at the surface (Fig. 5.5(c), Fig. 5.6(c) and Fig. 5.7(b)). Microvilli found at the summit of each papilla represent the taste hairs originating from the sensory cells of the taste buds (Tripathi and Mittal, 2010). Reutter *et al*., (1974), believed that the taste buds within epidermal papillae may act both as chemoreceptors and mechanoreceptors. Study by Kiyohara *et a*l., (1980), on the distribution of taste buds on the lips and inside the mouth of minnow, *Pseudorasbora parva*, reveal that the highest concentrations of taste buds are inside the mouth, gill arches and rakers and suggested that the minnow use the lips, gills and palatal organ as its main taste organ. Komada, (1993) and Yashpal *et al*., (2006) stated that for carnivorous fish, *Oncorhynchus rhodurus* and *Rita rita,* respectively, the function of the different types of taste buds is probably detection and analysing of taste substances, as well as for assessing the quality and palatability of food, during food manoeuvring and swallowing.

As shown in Figure 5.7(c), *L. festivus* is also equipped with microridges or also called microvillar ridges, microplicae and cytoplasmic folds (Sperry, 1976), in the posterior region of the palate. The compact microridge structures in this region is important for protection against physical abrasions, potentially caused during food manoeuvring final selection, handling, swallowing and propelling the food particles toward the esophagus with the aid of mucous cell secretion, (Yashpal *et al*., 2006 and 2009). Study by Sperry and Wassersug (1976), discovered that the microridges help hold a protective coat of mucus to the epithelium. Wilson and Castro (2011), suspected the microridges play major rule to improve mucus adherence and spread and also to minimise impact damage to the epithelium.

Another important structure of fish mouth part used for straining food and other materials from passing water through them are the gill rakers. The gill rakers also protect the gill filaments from damage. Munshi *et al*., (1984) discovered *Cirrhinus mrigala* (carp) has densely packed flap-like gill rakers to suit the detritivorous habit of the fish. Their gill rakers are small, villiform shaped, laterally spread and set so closely that they prevent almost everything from passing through, with the exception of water. Other species which consume mainly small particles of detritus, mud and small organisms are *Prochilodus lineatus, Steindachnerina insculpta* and *Trachydoras paraguayensis* reported by Fugi *et al*., (2001), have the rakers close together in order to prevent loss of food through the gill. Figure 5.8 and Figure 5.9 shows that *L. festivus* has short gill rakers and with spacing between adjacent rakers not very close. This could suggest that they consumed large food items such as large detritus and plankton, and therefore could be generalised as omnivores. Gerking (1994), in his book stated that fish with short gill rakers can and do feed on plankton, while those with long gill rakers can and do feed on bottom organisms. Admundsen *et al*., (2004), discovered that in two morphs of whitefish (*Coregonus lavaretus*) in sympatry, the sparsely-rakered morph most of the time inhabit littoral zone and feeding on zoobenthos, whereas the densely-rakered morph dominate in the pelagic zone and predominantly feed on zooplankton.

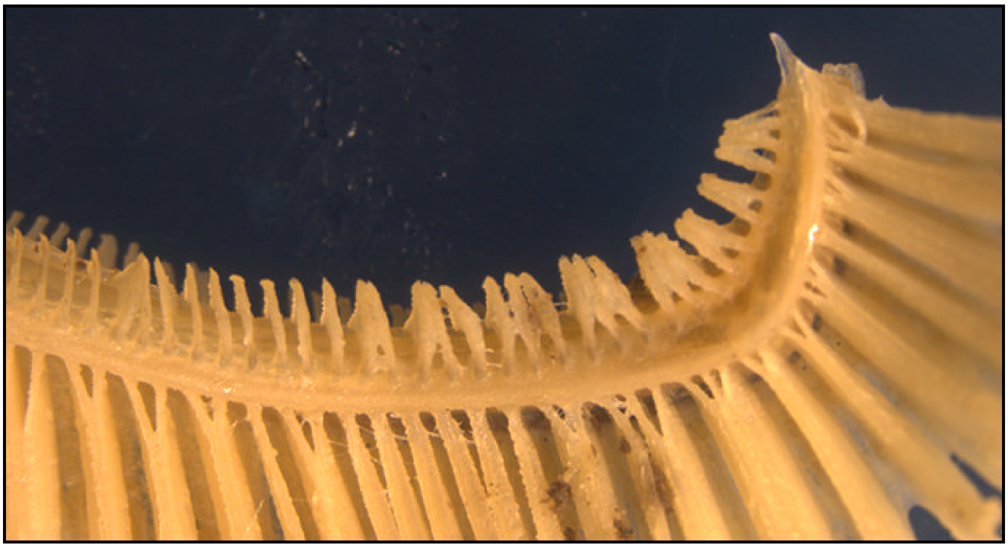


Figure 5.8 First gill arch of *Labiobarbus festivus*.

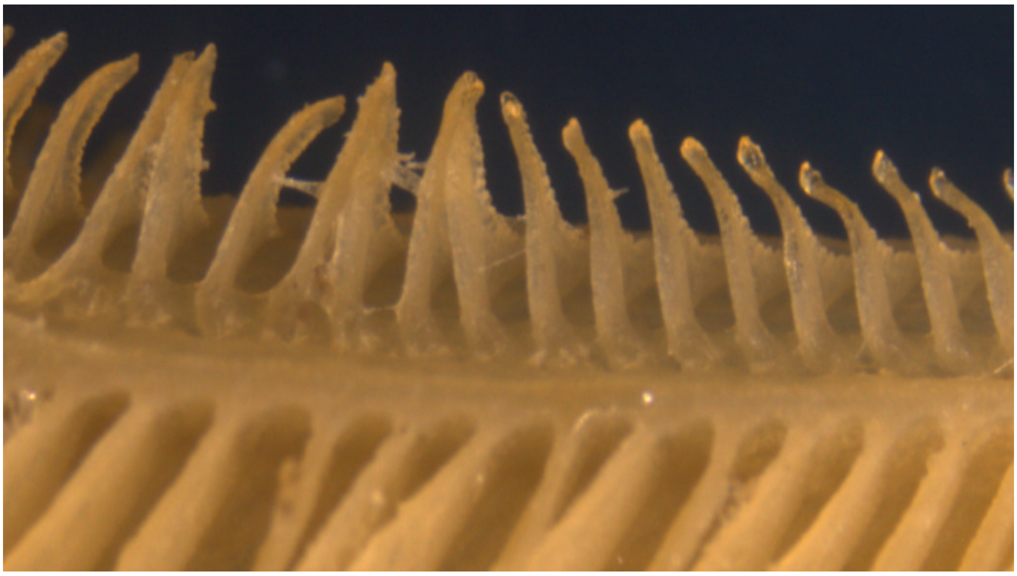


Figure 5.9 Gill rakers of *Labiobarbus festivus*.

5.4.2 Relative Importance Index of stomach contents

Relative Importance Index (%) of *L. festivus* from the present study shows that algae represented 55.7%, followed by detritus and plant (26.8%) and zooplankton (17.5%) of the diet (Table 5.1). Figure 5.10 to Figure 5.13 shows some of the detritus, algae and zooplankton that are commonly found in the stomach contents. Bacillariophyta is the most important component in terms of numbers (Fig. 5.14) whereas detritus and plant contributed more than 50% in terms of volume (Fig. 5.15). The Relative Importance Index report by Yap (1988) of this species was algae 34.3%, detritus and plant 34.52% and crustacean 34.1%. There are some factors that need to be considered for the differences such as fish size, stocking, the availability of the different food items, light intensity (Younga *et al*., 1997 and Bjornsso, 2001), and water temperature (Marchand *et al*., 2002) at that particular habitat and method used to sample fish. The catches for the recent study at Tasek Bera only used gill nets whereas for studies at Bukit Merah Reservoir, fish were purchased from fishermen that used various gears such as cast net, lift net and angling. Use of active capture methods such as electrofishing, angling, or seining could show better results than the passive method of trammel and gill netting for stomach contents study (Schooley *et al.,* 2008 and Vinson & Angradi, 2011). From both research showed that algae and detritus are the most frequently consumed and important food for *L. festivus*.

Table 5.1 Number (N %), volume (V %), frequency (F %) and relative important index (R %) of *Labiobarbus festivus* from Tanjung Penarikan, Tasek Bera lake.

	Food Items									
	Bacillariophyta		Chlorophyta		Cyanophyta		Zooplankton (Cladocera/Copepoda)		Others (Detritus/Plant Materials)	
	% N	%V	% N	%V	% N	%V	% N	%V	% N	%V
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.57
2	3.54	0.65	6.25	2.18	0.00	0.00	0.36	0.17	0.01	0.44
3	0.55	0.21	0.11	0.06	0.00	0.00	0.11	0.06	0.01	0.01
4	0.05	0.02	0.11	0.05	0.00	0.00	0.08	0.07	0.01	0.26
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.49
6	2.85	1.62	0.49	0.22	0.00	0.00	0.41	0.37	0.01	4.77
7	3.07	0.95	0.36	0.20	0.00	0.00	0.02	0.01	0.01	0.61
8	1.78	0.84	2.36	0.49	0.00	0.00	0.24	0.00	0.01	0.45
9	1.79	0.59	1.21	0.70	0.00	0.00	0.30	1.57	0.01	2.90
10	2.28	0.47	0.85	0.36	0.00	0.00	0.03	0.02	0.01	1.62
11	2.39	1.10	0.96	0.49	0.00	0.00	0.25	0.25	0.01	3.10
12	1.40	0.48	0.24	0.13	0.00	0.00	0.11	0.35	0.01	1.93
13	1.79	0.72	0.87	0.37	0.00	0.00	0.22	0.16	0.01	1.63
14	3.34	0.70	0.91	0.37	0.00	0.00	0.33	0.20	0.01	1.21
15	0.65	0.12	0.08	0.04	0.00	0.00	0.03	0.02	0.01	1.46
16	3.51	0.53	4.20	1.03	0.00	0.00	0.49	0.20	0.01	0.30
17	0.20	0.03	0.05	0.03	0.00	0.00	0.05	0.18	0.01	1.41
18	0.19	0.07	0.02	0.01	0.00	0.00	0.05	0.07	0.01	3.14
19	1.39	0.49	0.16	0.08	0.00	0.00	0.22	0.19	0.01	1.71
20	1.01	0.33	0.08	0.10	0.00	0.00	0.20	0.26	0.01	0.54
21	1.05	0.42	0.20	0.11	0.00	0.00	0.09	0.16	0.01	1.79
22	0.69	0.13	0.03	0.02	0.00	0.00	0.05	0.02	0.01	1.06
23	0.20	0.04	0.03	0.02	0.00	0.00	0.00	0.00	0.01	0.76
24	1.26	0.26	0.14	0.12	0.00	0.01	0.17	0.24	0.01	1.02
25	0.05	0.04	0.00	0.00	0.00	0.00	0.02	0.07	0.01	0.71
26	4.28	1.10	0.85	0.43	0.00	0.01	0.30	0.60	0.01	2.39
27	1.37	0.27	0.47	0.21	0.00	0.00	0.31	0.21	0.01	0.95
28	0.57	0.80	0.06	0.03	0.00	0.00	0.08	0.06	0.01	0.76
29	3.21	1.14	0.63	0.35	0.00	0.03	0.27	0.35	0.01	0.59
30	1.31	0.45	0.41	0.25	0.00	0.00	0.27	0.21	0.01	1.55
31	0.44	0.14	0.11	0.16	0.00	0.00	0.08	0.06	0.01	0.46
32	1.39	0.87	0.99	0.82	0.00	0.00	0.16	0.14	0.01	0.18
33	1.43	0.63	0.55	0.38	0.00	0.00	0.30	0.20	0.01	2.49
34	2.58	1.10	1.97	1.39	0.00	0.00	0.16	0.12	0.01	0.56
35	2.25	1.20	0.35	0.18	0.00	0.00	0.22	0.30	0.01	0.38
36	1.54	0.86	0.99	0.79	0.00	0.00	0.13	0.14	0.01	1.91
37	0.27	0.19	0.06	0.07	0.00	0.00	0.03	0.04	0.01	0.53
38	0.24	0.11	0.08	0.05	0.00	0.00	0.00	0.00	0.01	0.66
39	0.24	0.16	0.03	0.02	0.00	0.00	0.05	0.02	0.01	0.63
40	0.14	0.07	0.06	0.00	0.00	0.00	0.09	0.10	0.01	0.65
41	0.55	0.14	0.42	0.45	0.06	0.00	0.03	0.01	0.01	0.22
42	0.42	0.21	0.57	0.39	0.03	0.02	0.05	0.04	0.01	0.29
43	0.02	0.01	0.09	0.06	0.00	0.00	0.00	0.00	0.01	0.43
44	0.50	0.21	0.61	0.50	0.00	0.00	0.05	0.03	0.01	0.13
45	0.80	0.29	0.82	0.56	0.03	0.01	0.30	0.31	0.01	0.29
46	0.27	0.02	0.54	0.00	0.00	0.00	0.02	0.00	0.01	0.80
47	0.20	0.10	0.00	0.19	0.00	0.00	0.16	0.37	0.01	0.36
48	0.14	0.49	0.03	0.60	0.00	0.00	0.08	0.16	0.01	0.94
49	0.25	0.72	0.11	0.00	0.00	0.00	0.02	0.34	0.01	0.01

Table 5.1(continued)

50	0.03	0.16	0.02	0.31	0.00	0.00	0.08	0.01	0.01	0.33
51	0.00	0.13	0.02	0.00	0.00	0.00	0.00	0.00	0.01	1.18
52	0.17	0.08	0.30	0.02	0.00	0.00	0.24	0.07	0.01	1.29
53	0.47	0.13	0.50	0.19	0.00	0.00	0.08	0.02	0.01	0.06
54	0.00	0.02	0.33	0.00	0.00	0.00	0.28	0.12	0.01	0.07
Tot	60.1	22.61	31.6	15.5	0.12	0.08	7.67	8.67	0.54	54.98
% F	98.15		85.19		9.26		85.19		100	
RIa	**31.19**		**22.84**		**1.63**		**17.51**		**26.82**	

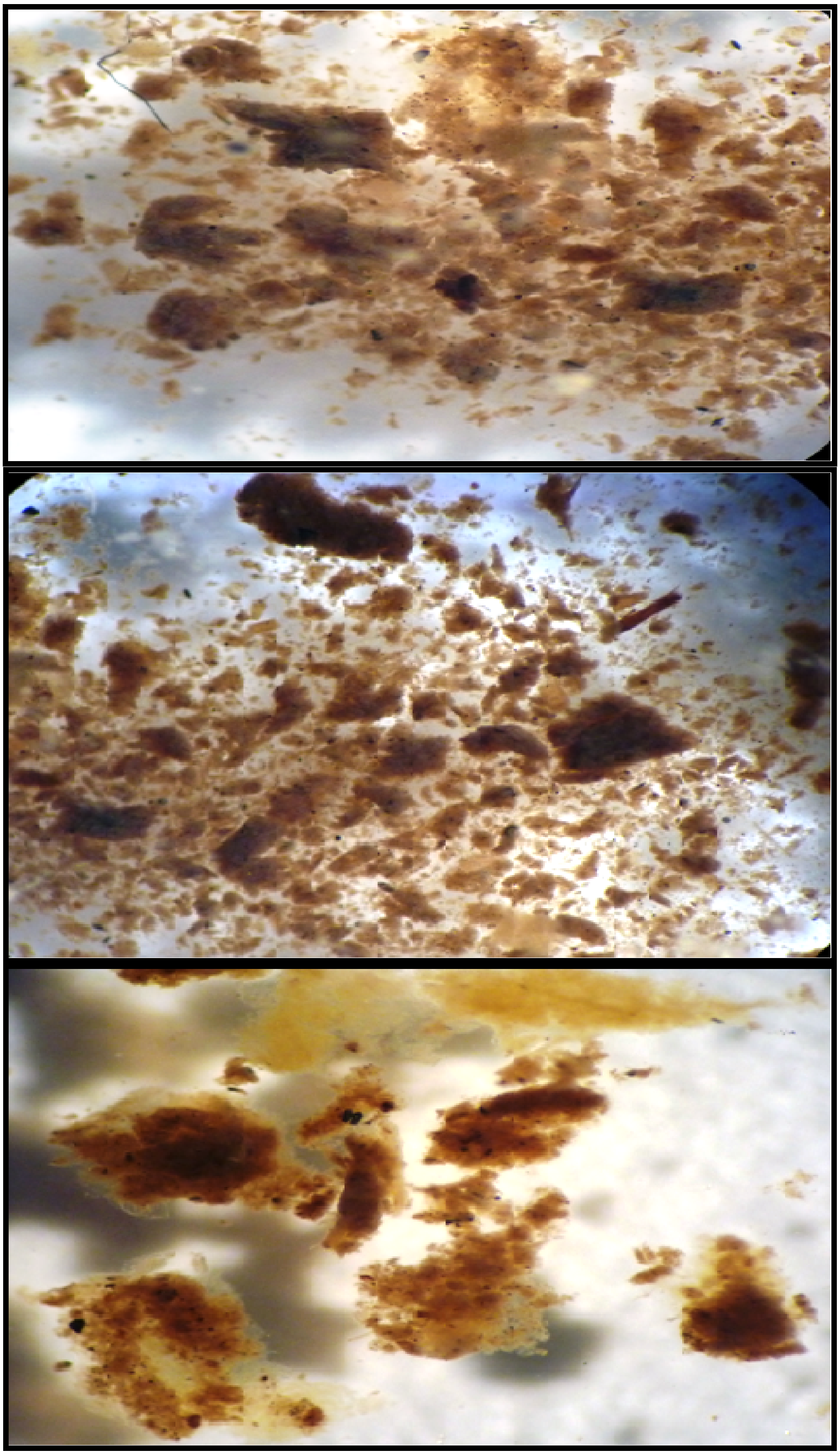


Figure 5.10 Detritus in the gut of *Labiobarbus festivus*.

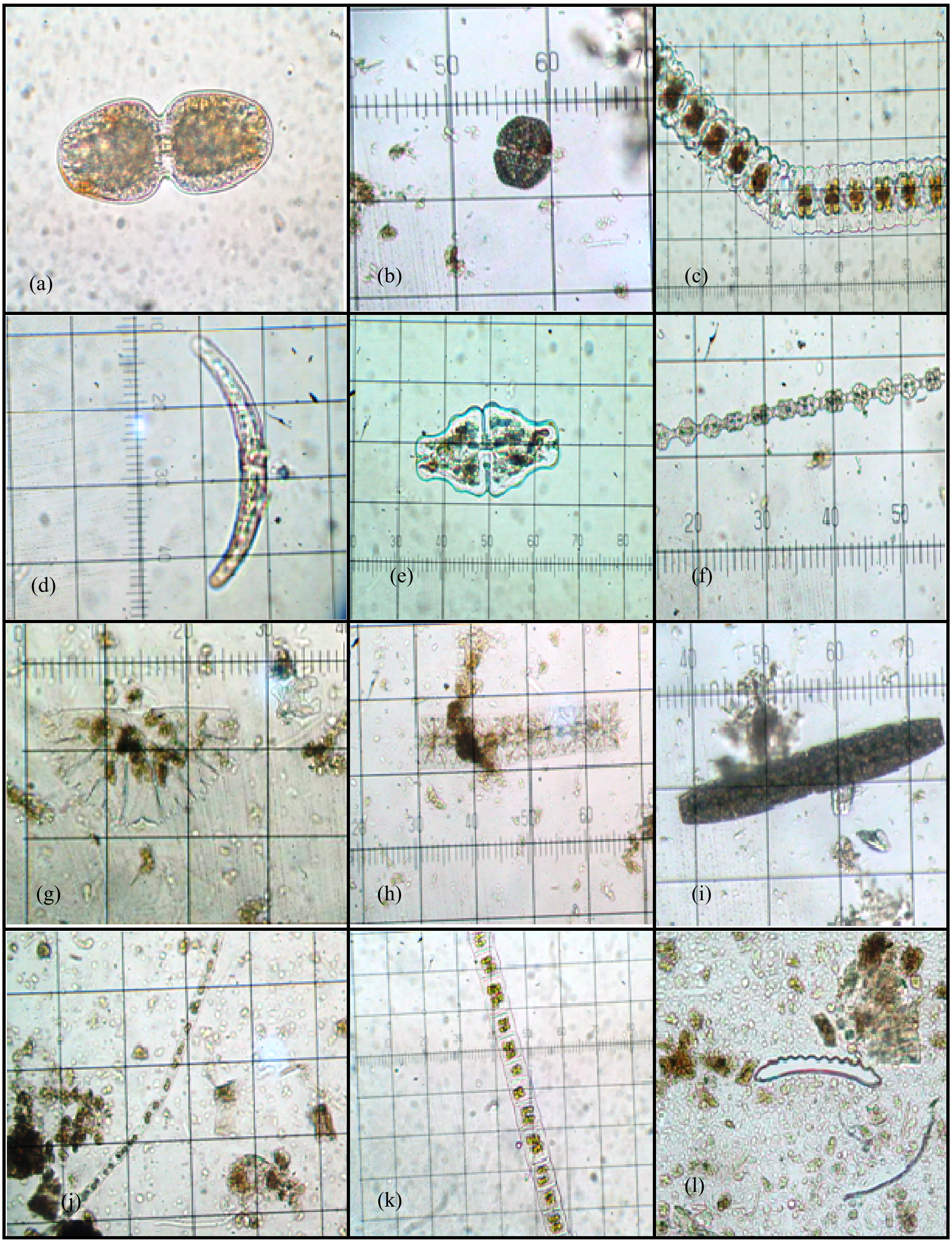


Figure 5.11 Some algae occurring in the gut of *Labiobarbus festivus*. Division Chlorophyta (a: *Cosmarium* sp.; b: *Cosmarium* sp.; c: *Desmidium* sp.; d: *Closterium* sp.; e: *Euastrum* sp.; f: *Gymnozyga* sp.; g: *Micrasterias* sp.; h: *Micrasterias* sp.; i: *Pleurotaenium* sp.; j: *Zygnema* sp.; k: *Zygnema* sp.) and Division Chrysophyta (l: *Eunotia* sp.).

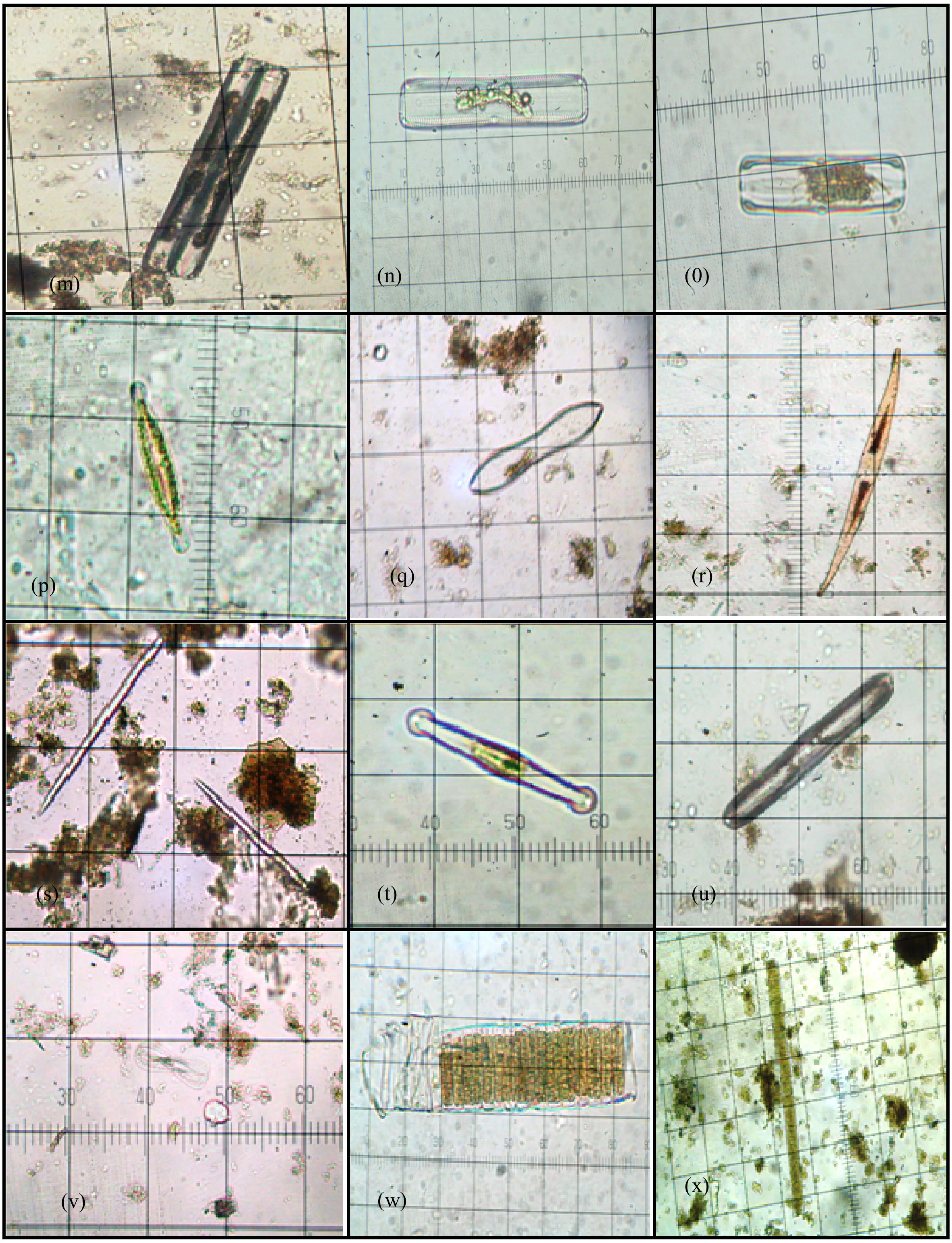


Figure 5.12 Some algae occurring in the gut of *Labiobarbus festivus*. Division Chrysophyta (m: *Fragelaria* sp.; n: *Fragelaria* sp.; 0: *Fragelaria* sp.; p: *Fragelaria* sp. ; q: *Synedra* sp.; r: *Nitzschia* sp.; s: *Synedra* sp.; t: *Pinnularia* sp.; u: *Pinnularia* sp.; v: *Surirella* sp.) and Division Cyanophyta (w & x: *Oscillatoria* sp.).

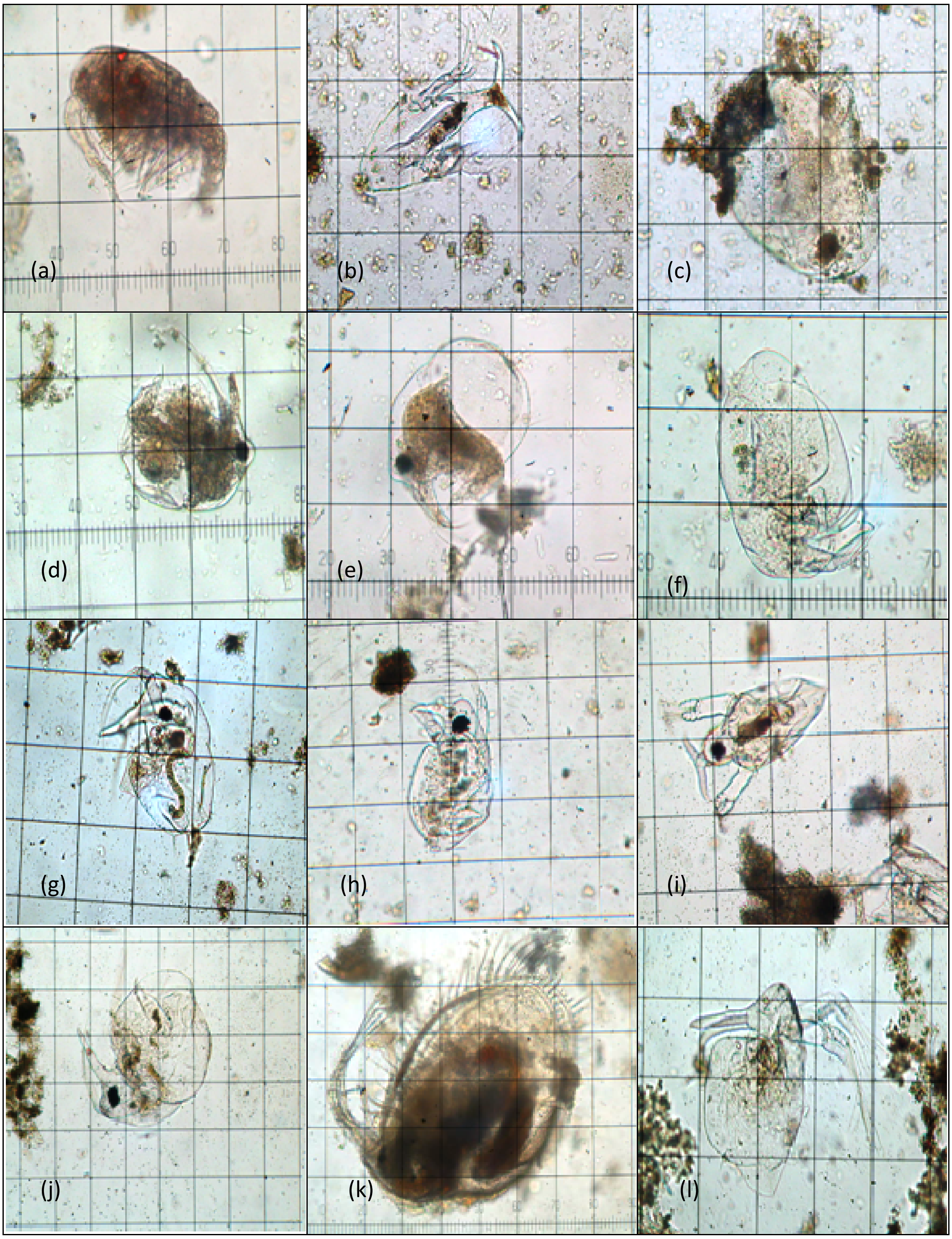


Figure 5.13 Some of zooplankton occuring in the gut of *Labiobarbus festivus*. (a: *Thermocyclops* sp.; b & c: unidentified; d: *Bosminopsis* sp.; e: *Bosminopsis* sp.; f: *Bosminopsis* sp.; g: *Diaphanosoma* sp.; h: *Diaphanosoma* sp.; i: *Diaphanosoma* sp.; j: *Diaphanosoma* sp.; k: Ilyocrptus sp.; l: *Moina* sp.).

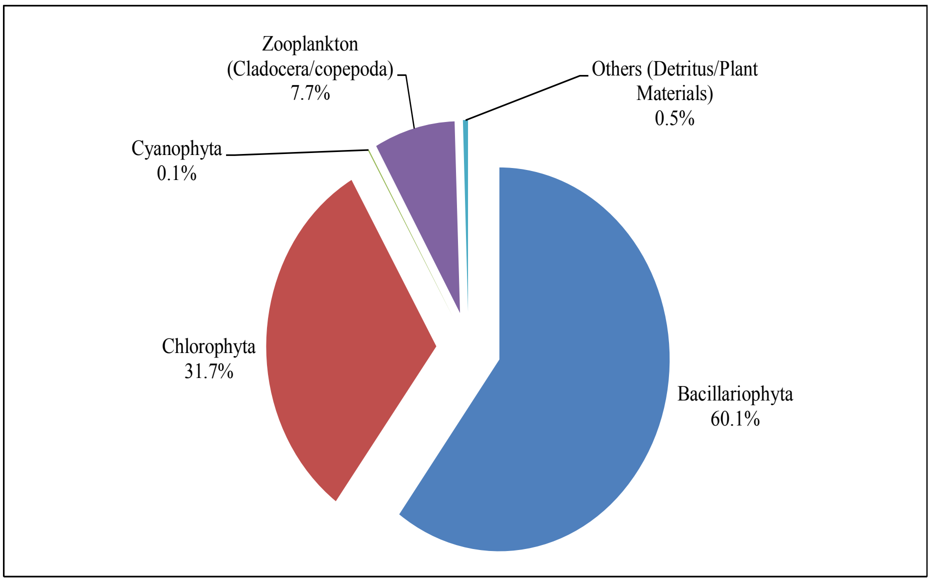


Figure 5.14 The composition (% according to number) of various main food items in stomach of *Labiobarbus festivus*.

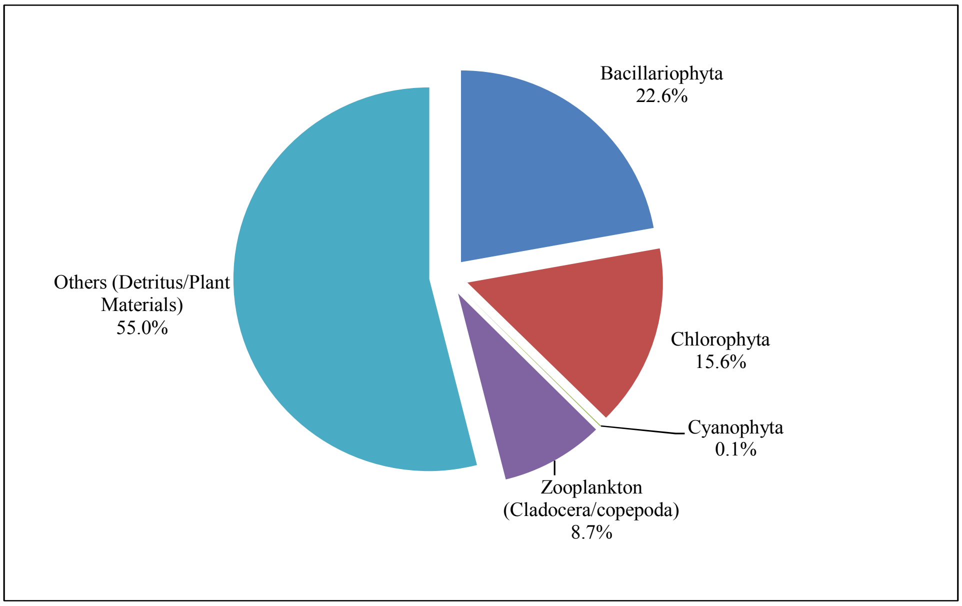


Figure 5.15 The composition (% according to volume) of various main food items in stomach of *Labiobarbus festivus*.

CHAPTER 6

GENERAL DISCUSSION

Tasek Bera wetland plays a major role in controlling floods, regulating flow, and purifying water by reducing sediment and retaining nutrient. It is an important habitat for fishes (95 species), turtles (10 species) and 374 plant species (O'Connor, 1999). Biodiversity of Tasek Bera wetland contributes to Malaysia's mega-diversity of flora and fauna, which consist of more than 15,000 flowering plants, 286 mammals, 150,000 invertebrates and 4000 marine fish (MOSTE, 1997).

Tasek Bera wetland is heavily influenced by development in the surrounding areas. The main agricultural activity here is oil palm plantation that contributes pollutants such as sediment from soil erosion, nutrients (nitrates and phosphorus) from fertiliser usage, pesticides and pathogens. The impact of those pollutants may cause an enrichment of nutrient that triggers alga blooms. The decomposition of dead algae and their night respiration can deplete oxygen in the water. This phenomenon, in turns, kills fish and other aquatic organisms.

A recent inventory of the plants at Tasek Bera wetland resulted in the discovery of more than 800 species of vascular plants from 400 genera and 128 families (Rafidah *et al*., 2010). Tasik Chini wetland, which is also situated in Pahang, Malaysia has similar vegetation with Tasek Bera. A dam, which was built at its outlet, has resulted in the deterioration of its surrounding area. Now, only Tasek Bera wetland remains as a pristine water body in Peninsular Malaysia (Rafidah *et al.,* 2010). This is the most important reason why this Ramsar site should be managed in such a way that the existing flora and fauna of the area are protected and conserved.

Deforestation is a major factor in causing the increment in water temperature of the wetland as compared to 30 years ago. Effects of deforestation on local climate have been studied by many researches (Meher-Homji, 1991; Henderson-Sellers *et al*., 1993; Malhi *et al*., 2008; Lee *et al*., 2011). Some important parameters that significantly affect the fish from climatic change are the rise in temperature, pollutants and the ultraviolet light, and the reduction in dissolved oxygen of the water (Ficke *et al.,* 2007).

Deforestation has also increases nutrient loading (Feller, 2010). Surface runoff, particularly from the exposed land, brings together silt and sediment into the water. It will significantly change the water turbidity. Increased concentration of sediment in the water is harmful to fish and fish habitat. Abrasion of the gills of fish and other aquatic organisms is a common occurrence (Alabaster and Llyod, 1980). Other negative impacts include behavioural changes, including movement and migration (Bilotta and Brazier, 2008), decrease resistance to disease (Bergstedt and Bergersen, 1997), poor egg and fry development (Partridge and Michael, 2010) and fatal impact to small aquatic animals that are food to fish (Danoho and Molinos, 2009).

Deforestation has increased the acidity of the lake throughout the 30 year period. Increased hydrogen ion release is taking place from leaching from peat soil surrounding the area once a forest is cleared. Land clearing activities may have also increased the amount of detrital biomass, encouraging decomposition processess to increase the biological oxygen demand. Acidic conditions could also be the result of nutrient loading of the soil (Feller, 2010). Certain fishes have an unusually high level of tolerance to low pH. This is shown by small cardinal characin (*Cheirodon axelrodi*), neon (*Hyphessobrycon innesi*) and emperor tetras (*Nematobrycon palmeri*) that are often found in acidic blackwater rivers (Dunson *et al.,* 1977). However, waters with too low acidity could kill fish directly or indirectly (Kibria, 2011). The inability of planktonic organisms, a major source of food for fish, to survive in waters with low pH value will affect the fish population. When this happens, the population of fish will be reduced (Liu, 2005); their young normally have difficulty to stay alive (Liu, 2005). Findings of Lorenz and Taylor (1992) show a significant alteration in brooding behaviours and aggressiveness of the cichlid (*Cichlasoma nigrofasciatum*) at low pH. The possibility of phosphate enrichment is interesting as tropical freshwater systems tend to be phosphate limited and addition of phosphates often encourage the balance to shift towards nitrogen limited ecosystem. This could also be the reason for lower recorded levels of nitrate and ammonium as compared to earlier studies in Tasek Bera.

Although there has been no study on the effect of herbicides such as Paraquat, Sentry and Ally used at the surrounding area on the community of aquatic organisms of Tasek Bera wetland, their negative impact cannot be ruled out. It has been known that these chemicals kill fish and wildlife (Sinhaseni and Tesprateep, 1987; Ogama *et al.,* 2011). They are also biomagnified in the food web (Kid *et al*., 2001). The present study has managed to record 95 species with 14 new records of fishes in Tasek Bera wetland, one of the Ramsar sites in Malaysia. This shows that this extremely unique freshwater habitat is the home for many species of fish. Ng *et al*., (1994b) strongly suggested that the black water peat swamp should be protected to ensure the perpetual existence of this rich and unique ecosystem. However, based on records inclusive of the current study, a total of 144 species had been recorded in the area (this includes several species that were only identified up to the genus level and redundant species). The current study also noted that out of a total 95 species collected during field collections and inspected at UMKL and ZRC, at least 4 species had not been recorded during the last 30 years and can be considered locally extinct, while another 66 species were considered to be rare or extremely rare. Only 20 species were recorded to be common and an additional five species as abundant. Based on these numbers, it could be that the surrounding activities had impacted the fish population in Tasek Bera. A lower oxygen level as compared to earlier studies, as well as the concentration of fish diversity and biomass in the surface waters (0-2 metres), may be the outcome of some of the anthropogenic change that is taking place. In addition, a study conducted by Mizuno and Furtado (1982) listed *Botia hymenophysa* as a common species, was however recorded as extremely rare in this study along with several other Cobitidae species. These species are extremely popular in the aquarium trade and could have been fished out extensively.

A species that was recorded in abundance, *Labiobarbus festivus* was observed to be an omnivore, feeding heavily on algae and detritus. Algae absorb nutrients from the water column and accelerate its growth. This would provide abundant food supply for this species alongside the increased organic detritus from land clearing activities, hence increasing the successfulness of this species.

Although implementations of the integrated management plan for this area has just begun, more engagement to local community residing within the area (Orang Asli Semelai) needs to be carried out. At present, they do not fully understand the benefit of conserving their area without affecting their livelihood. Intensive educational programme should be given to them so that they can become the guardian of their homeland.

Some of the important aspects that should be taken into account in order to protect Tasek Bera Ramsar site are long term monitoring of water quality, erosion control measures, maintaining vegetative growth at buffer zone, use of biological pest control and livestock management (O' Connor, 1999). In order to successfully achieve the goal, cooperation from government agencies such as MOSTE (replaced by Ministry of Natural Resource and Environment - NRE), FELDA and educational institution with local people is vital.

CHAPTER 7

CONCLUSION

1. Water quality parameters were investigated in 11 sampling sites over a period of one year. Temperature recorded from this study ranged from 27.3^0C to 30.31^0C, total suspended solids (TSS) ranged from 3.27 to 44.91 mg/L, turbidity ranged from 4.02 to 20.49 NTU, total dissolved solids (TDS) ranged from 27.98 to 35.07 mg/L, conductivity ranged from 42.25 to 49.93 µS/cm, dissolved oxygen (DO) ranged from 2.02 to 5.25 mg/L, pH ranged from 5.0 to 6.6, hydrogen sulphide less than 7.5 µg/L, nitrite ranged from 1.29 to 20.00 µg/L, ammonium ranged from 7.50 to 123.40 µg/L and ammonia ranged from 0.005 to 0.91 µg/L.
2. Temperature and conductivity has shown an increase from earlier studies, while turbidity, ammonium and nitrates recorded a decrease. The range and mean of most of the other parameters were large and similar to past records. Land clearing and introduction of phosphate rich fertilisers may play a role in changing the parameters over the last 30 years.
3. Ninety five species from 22 families were recorded in Tasek Bera as a result of compilation of new specimens caught from the present study and preserved specimens deposited in the Museum of Zoology of the Science Faculty, University of Malaya and Zoological Reference Collection, National University of Singapore. Four species were considered to be locally extinct, while 39 and 27 species respectively, were considered to be extremely rare and rare.
4. Based on the present study and literature, a total of 144 species has been reported from Tasek Bera. However, this figure is inconclusive as several species were doubtful occurrences and redundant or incomplete identifications. Specimens of past surveys were not available to allow confirmation.

5. Fourteen species are new records for Tasek Bera; they include *Acanthopsoides molobrion, Akysis alfredi, Amblyrhynchichthys truncatus, Betta waseri, Boraras maculatus, Channa gachua, Chela laubuca, Epalzeorhynchos kalopterus, Kryptopterus moorei, Lepidocephalichthys furcatus*, *Macrochirichthys macrochirus, Macrognathus maculates, Osteochilus microcephalus,* and *Pangio malayana*.
6. The popular and expensive ornamental fish, *Scleropages formosus*, listed as endangered, still exist in Tasek Bera as it was caught in the present study. *Botia hymenophysa* from the family Cobitidae was recorded as a dominant species by Mizuno and Furtado (1982), but is now difficult to find.
7. Over 88% of all individual fish were captured within 3 m of the surface. Cyprinidae was the most abundant fish species-captured at every water level and the highest was at level 1 to 2 m from the surface (33.7%). Species composition in Tasek Bera was dominated by Cyprinidae which contributed 43%, followed by Siluridae and Osphronemidae, at 11% and 9.5%, respectively.
8. *Barbonymus schwanenfeldii, Cyclocheilichthys apogon, Hampala macrolepidota*, *Labiobarbus festivus* and *Kryptopterus apogon* occurred at almost every depth layers and only *Cyclocheilichthys apogon* and *Krpytopterus limpok* were caught at the deepest area which was 6 to 7 m from the surface.
9. Result from CCA shows that depth, dissolved oxygen and pH appeared as the most important parameters, as their arrow lengths were the longest among others. This indicates their relative importance in explaining variation in species data.
10. *Labiobarbus festivus* was the most abundant species with wide vertical distribution throughout the 24 hours sampling showing that majority of them were found in the 1-2 m depth layer.
11. Based on stomach content analysis, *Labiobarbus festivus* is an omnivore, feeding mainly on algae, detritus, plant and a small amount of zooplankton.

12. *Labiobarbus festivus* has a long and complex gut coiling and absence of stomach, and is replaced with intestinal swelling suitable for digesting plant matter. The mouth part of *Labiobarbus festivus* is weakly protrusible and ventrally directed when fully extruded. This is well adapted to its bottom detritus feeding habit.
13. The rows of unculi structure at lower and upper lips of *L. festivus* shows that this species is a periphyton feeder as this structure used to scraped the algae from the attached substrates. The gill rakers are short with spacing between adjacent rakers not very closely set in *L. festivus* and this could suggest that they consumed large food item.
14. The various morphological adaptation allow *L. festivus* to maximise on the available food resources of detritus and alga found in the area.

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Appendix 1 Rainfall data for 2004 obtained from the Department of Irrigation and Drainage of Malaysia

hujan kuala bera
9-APR-2008 11:19

~~~ NIWA Tideda ~~~ JPS Ampang
~~~ PDAY ~~~ VER 1.9
Source is C:\Documents and Settings\abusalim\Desktop\MIX\hujan pahang.mtd
24 hour periods beginning at 8:00:00am each day.
Daily totals Year 2004 site 3325086 KG. KUALA BERA at PAHANG
Rain mm

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	?	0.0	0.0	20.5	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.0	
2	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	
3	0.0	0.0	7.5	11.0	56.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
4	5.5	0.0	5.5	0.0	0.0	10.5	11.5	0.0	0.0	0.0	8.5	0.0	
5	13.0	0.0	0.0	0.0	4.0	0.0	24.5	0.0	0.0	0.0	21.0	0.0	
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	2.0	0.0	
8	0.0	0.0	21.0	0.0	0.0	0.0	0.0	0.0	0.0	35.0	11.5	0.0	
9	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5	0.0	
10	0.0	0.0	8.5	0.0	8.0	0.0	10.0	0.0	0.0	0.0	0.0	20.5	
11	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	16.0	
12	0.0	0.0	9.0	0.0	0.0	0.0	21.5	0.0	0.0	11.0	0.0	4.0	
13	0.0	0.0	84.0	0.0	0.0	0.0	0.0	22.0	41.0	44.0	0.0	0.0	
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
15	0.0	0.0	1.5	0.0	0.0	13.5	0.0	6.0	0.0	0.0	7.5	0.0	
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	4.0	0.0	
17	0.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.0	
18	7.5	0.0	7.0	0.0	0.0	0.0	0.0	0.0	17.0	0.0	20.5	0.0	
19	0.0	0.0	2.0	0.0	0.0	0.0	0.0	15.0	0.0	0.0	0.0	0.0	
20	0.0	0.0	40.5	0.0	0.0	0.0	0.0	4.5	0.0	27.0	0.0	0.0	
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.5	0.0	0.0	
22	0.0	0.0	0.0	11.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.0	0.0	0.0	0.0	
24	0.0	0.0	0.0	0.0	19.0	0.0	0.0	19.0	30.0	21.0	0.0	0.0	
25	0.0	0.0	0.0	11.0	0.0	33.5	0.0	0.0	0.0	41.0	0.0	0.0	
26	28.5	0.0	0.0	16.5	0.0	0.0	0.0	0.0	0.0	4.0	26.0	0.0	
27	35.5	0.0	0.0	0.0	0.0	0.0	24.5	0.0	4.0	31.5	0.0	0.0	
28	11.5	0.0	0.0	6.5	0.0	0.0	0.0	0.0	23.5	0.0	2.0	15.5	
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	24.5	
30	13.0		9.0	0.0	18.5	3.0	0.0	0.0	8.5	18.0	0.0	12.5	
31	2.0		0.0		17.0		0.0	0.0		0.0		3.5	
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot	118.5	6.0	199.5	77.5	122.5	60.5	92.0	70.5	157.0	270.0	127.0	106.5	1407.5
Max	35.5	6.0	84.0	20.5	56.0	33.5	24.5	22.0	41.0	44.0	26.0	24.5	84.0
NO>0.0	9	1	12	7	6	4	5	6	9	12	13	8	92

Appendix 2 Rainfall data for 2005 obtained from the Department of Irrigation and Drainage of Malaysia

hujan kuala bera

Daily totals Year 2005 site 3325086 KG. KUALA BERA at PAHANG
Rain mm

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.0	0.0	
2	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	
3	0.0	0.0	0.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	47.0	
4	0.0	0.0	0.0	0.0	22.0	6.0	0.0	0.0	0.0	18.0	0.0	20.5	
5	0.0	0.0	13.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	34.0	
6	0.0	0.0	0.0	0.0	7.5	0.0	20.0	0.0	54.0	0.0	0.0	0.0	
7	0.0	0.0	0.0	23.5	0.0	0.0	0.0	0.0	0.0	0.0	9.0	84.5	
8	35.5	0.0	0.0	0.0	0.0	10.5	7.5	0.0	0.0	0.0	0.0	0.0	
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.0	0.0	
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	74.5	
11	0.0	0.0	0.0	0.0	0.0	14.5	0.0	0.0	0.0	0.0	13.0	3.0	
12	0.0	0.0	0.0	0.0	0.0	0.0	15.5	0.0	44.0	0.0	14.0	3.5	
13	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	13.5	0.0	
14	0.0	0.0	0.0	8.0	0.0	10.5	19.5	0.0	0.0	10.5	0.0	0.0	
15	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0	33.0	0.0	0.0	
16	0.0	0.0	0.0	0.0	31.5	0.0	5.5	33.5	0.0	0.0	25.0	11.5	
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5	0.0	20.0	0.0	
18	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	7.0	0.0	26.0	0.0	
19	0.0	0.0	0.0	0.0	9.0	23.0	18.0	17.5	0.0	0.0	10.0	0.0	
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	63.0	21.5	38.5	
21	0.0	0.0	6.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	23.5	0.0	
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0	0.0	0.0	0.0	
23	0.0	0.0	0.0	4.5	8.0	0.0	0.0	0.0	66.0	0.0	0.0	0.0	
24	0.0	0.0	0.0	0.0	0.0	0.0	23.0	8.0	3.0	0.0	0.0	6.0	
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
26	0.0	46.5	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	27.5	22.0	
27	0.0	0.0	0.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	
28	0.0	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
29	0.0		12.0	0.0	0.0	0.0	0.0	0.0	35.0	13.5	0.0	0.0	
30	0.0		0.0	0.0	0.0	0.0	0.0	0.0	5.5	9.0	0.0	0.0	
31	0.0		20.5		0.0		0.0	0.0		0.0		6.0	
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot	35.5	46.5	52.0	74.5	87.0	69.5	112.0	59.0	246.0	147.0	269.0	353.0	1551.0
Max	35.5	46.5	20.5	23.5	31.5	23.0	23.0	33.5	66.0	63.0	32.0	84.5	84.5
NO>0.0	1	1	4	7	7	6	8	3	11	6	16	13	83

Appendix 3 **S**elected physical and chemical parameters measured at Tasek Bera during the study period from April 2004 to December 2005 at every metre depth interval.

Depth (m)		Temperature (^{0}C)	Total Suspended Solid	Total Dissolved solid	Turbidity (NTU)	Conductivity (microS)	Dissolved Oxygen (mg/L)	pH	Hidrogen sulphide (µg/L)	Nitrite (µg/L)	Ammonium (µg/L)	Ammonia (µg/L)
0 to 1	N	111	111	111	111	111	111	111	64	64	64	64
	Mean	29.80	12.24	31.03	6.75	46.31	3.83	5.60	0.78	3.28	57.97	0.45
	Minimum	26.25	1.00	23.00	2.50	36.00	1.26	4.14	0.00	0.00	0.00	0.00
	Maximum	32.07	67.00	41.00	20.60	57.00	6.34	7.24	10.00	30.00	230.00	1.87
	SD	1.57	14.86	4.21	3.82	5.73	1.31	0.85	2.70	6.44	66.31	0.64
1 to 2	N	177	177	177	177	177	177	177	111	111	111	109
	Mean	29.72	13.89	30.56	8.71	45.02	3.91	5.72	1.26	2.34	68.92	0.44
	Minimum	26.27	1.00	23.00	2.70	35.00	1.24	4.3	0.00	0.00	0.00	0.00
	Maximum	31.14	132.00	42.00	29.90	56.00	6.34	8.6	10.00	10.00	220.00	1.79
	SD	0.98	19.13	4.29	5.83	5.63	1.38	0.78	3.33	4.25	54.86	0.46
2 to 3	N	93	93	93	93	93	93	93	72	72	72	72
	Mean	29.18	29.73	32.20	7.92	44.01	3.39	5.82	0.83	5.28	88.89	0.35
	Minimum	27.33	1.00	25.00	2.60	35.00	1.53	4.3	0.00	0.00	0.00	0.00
	Maximum	31.02	188.00	47.00	17.00	58.00	6.22	7.01	10.00	20.00	350.00	1.14
	SD	0.90	39.22	4.59	3.47	5.49	1.11	0.71	2.78	6.71	87.24	0.35
3 to 4	N	24	24	24	24	24	24	24	19	19	19	19
	Mean	28.96	15.13	36.04	7.51	42.54	3.19	5.96	0.53	15.26	71.58	0.27
	Minimum	27.1	1.00	27.00	3.00	35.00	0.93	4.7	0.00	10.00	0.00	0.00
	Maximum	30.37	43.00	47.00	12.20	54.00	4.5	6.7	10.00	100.00	130.00	0.70
	SD	0.90	12.27	4.21	2.70	6.39	0.98	0.70	2.29	20.65	54.08	0.31
4 to 5	N	10	10	10	10	10	10	10	10	10	10	10
	Mean	28.53	13.00	43.40	7.45	49.40	3.14	5.84	0.00	14.00	36.00	0.03
	Minimum	27.17	5.00	36.00	5.40	40.00	2.60	5.48	0.00	0.00	0.00	0.00
	Maximum	29.20	27.00	56.00	14.80	57.00	3.87	6.37	0.00	100.00	100.00	0.07
	SD	0.59	7.38	6.42	2.72	6.69	0.56	0.36	0.00	30.62	36.27	0.03
5 to 6	N	18	18	18	18	18	18	18	18	18	18	18
	Mean	28.95	63.94	32.67	7.82	44.00	2.54	6.25	3.89	5.00	44.44	0.28
	Minimum	26.77	18.00	29.00	6.00	35.00	1.92	5.34	0.00	0.00	0.00	0.00
	Maximum	29.54	130.00	40.00	10.00	56.00	3.20	6.70	10.00	20.00	140.00	0.70
	SD	0.75	54.44	4.28	1.13	3.71	0.28	0.40	5.02	6.18	51.59	0.32
6 to 7	N	4	4	4	4	4	4	4	4	4	4	4
	Mean	28.95	45.00	35.00	8.00	40.00	3.90	5.80	0.00	0.00	100.00	0.24
	Minimum	28.95	45.00	35.00	8.00	40.00	3.90	5.80	0.00	0.00	100.00	0.24
	Maximum	28.95	45.00	35.00	8.00	40.00	3.90	5.80	0.00	0.00	100.00	0.24
	SD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix 4 Selected physical and chemical parameters measured at Tasek Bera during the study period from April 2004 to December 2005, recorded during the 3 time intervals in a day.

Time		Temperature (^0C)	Total Suspended Solid (mg/L)	Total Dissolved solid (mg/L)	Turbidity (NTU)	Conductivity (microS)	Dissolved Oxygen (mg/L)	pH	Hidrogen sulphide (µg/L)	Nitrite (µg/L)	Ammonium (µg/L)	Ammonia (µg/L)
0600 hours	N	186	186	186	186	186	186	186	127	127	127	127
	Mean	29.17	17.25	31.90	7.51	45.52	3.76	5.81	0.71	5.43	82.05	0.45
	Minimum	26.25	1.00	23.00	3.10	35.00	1.40	4.30	0.00	0.00	0.00	0.00
	Maximum	30.64	67.00	42.00	17.00	56.00	6.22	8.60	10.00	30.00	350.00	1.87
	SD	1.09	19.54	4.30	2.97	6.08	1.14	0.85	2.58	6.64	80.58	0.56
1400 hours	N	54	54	54	54	54	54	54	38	38	38	38
	Mean	29.70	13.63	32.24	6.66	45.39	3.61	5.41	0.79	8.95	73.42	0.45
	Minimum	27.17	1.00	25.00	2.50	35.00	0.93	4.14	0.00	0.00	0.00	0.00
	Maximum	31.59	28.00	56.00	14.80	56.00	6.06	6.50	10.00	100.00	180.00	1.14
	SD	1.13	9.18	6.93	2.10	5.81	1.39	0.59	2.73	22.27	66.51	0.50
2200 hours	N	197	197	197	197	197	197	197	133	133	133	131
	Mean	29.80	22.64	31.47	8.62	44.43	3.59	5.79	1.58	2.56	56.17	0.30
	Minimum	27.08	1.00	23.00	2.50	35.00	1.24	4.50	0.00	0.00	0.00	0.00
	Maximum	32.07	188.00	47.00	29.90	58.00	6.34	7.40	10.00	20.00	160.00	1.14
	SD	1.18	36.76	4.74	6.03	5.31	1.37	0.70	3.66	4.87	47.21	0.32

Appendix 5 The latest valid family and species names mentioned in this thesis. (Following Eschmeyer Catalogue Fish Species Online Version Updated 4 January 2013)

No.	Species	Valid Family Name
1.	*Boraras maculatus*	Rasboridae
2.	*Chela laubuca*	Rasboridae
3.	*Leptobarbus hoevenii*	Leptobarbidae
4.	*Macrochirichthys*	Cultridae
5.	*Oxygaster anomalura*	Cultridae
6.	*Parachela hypopthalmus*	Cultridae
7.	*Parachela oxygastroides*	Cultridae
8.	*Parambassis apogonoides*	Ambassidae
9.	*Nemacheilus selangoricus*	Nemacheilidae
10.	*Pristolepis fasciata*	Pristolepididae

Valid species names

No	Species	Valid name	Valid Family Name
11.	*Botia hymenophysa*	*Syncrossus hymenophysa*	Cobitidae
12.	*Kryptopterus apogon*	*Phalacronotus apogon*	Siluridae
13.	*Monopterus albus*	*Monopterus javanensis*	Synbranchidae
14.	*Puntius binotatus*	*Systomus binotatus*	Cyprinidae
15.	*Puntius johorensis*	*Systomus johorensis*	Cyprinidae
16.	*Puntius lineatus*	*Systomus lineatus*	Cyprinidae
17.	*Puntius partipentazona*	*Systomus partipentazona*	Cyprinidae
18.	*Rasbora dorsiocellata*	*Brevibora dorsiocellata*	Rasboridae
19.	*Rasbora pauciperforata*	*Trigonopoma pauciperforatum*	Rasboridae
20.	*Trichogaster leerii*	*Trichopodus leerii*	Osphronemidae
21.	*Trichogaster trichopterus*	*Trichopodus trichpterus*	Osphronemidae

Note: The thesis was prepared based on the established names at the the time of writing.

List of Publications

Fatimah, A. Structure of the Fish Assemblage in Sungai Kemalai and Sungai Kering, Jelebu, Negeri Sembilan, Malaysia**.** *Malaysian Journal of Science.* **28**(4)**:** 446-450**.**

Zulaikha-Othman, S., Sulaiman, A. H, **Fatimah, A**. and Zakaria-Ismail, M. (2009). Water Quality and Classification of the Kenaboi River and its Tributaries in Negeri Sembilan, Malaysia. *Malaysian Journal of Science.* **28**(4)**:** 352-358**.**

Khaironizam, K. M., **Fatimah, A**., Fazimah, A. and Zakaria-Ismail, M. (2009). The Fish Fauna of the Kenaboi River, Jelebu, Negeri Sembilan, Malaysia. *Malaysian Journal of Science.* **28**(4)**:** 439-445.

Fazimah, A., **Fatimah, A**., Khaironizam, K. M. and Zakaria-Ismail, M. (2009). Drift of Aquatic Insects in Kenaboi, Negeri Sembilan, Malaysia. *Malaysian Journal of Science.* **28**(4)**:** 432-438**.**

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